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(2-01) p. 1 of 4

ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

OMB Control No. 1910-1400

PART I: STI PRODUCT DESCRIPTION
(To be completed by Recipient/Contractor)

A. STI Product Identifiers

1. REPORT/PRODUCT NUMBER(s)
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DE-FG36-03GO13124

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B. Recipient/Contractor

Makah Nation

C. STI Product Title

"Next Steps to Implement Renewable Energy Project on the Makah Indian Nation for the Pacific North West Region"

D. Author(s)

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E. STI Product Issue Date/Date of Publication

12/30/2005 (mm/dd/yyyy)

F. STI Product Type *(Select only one)*

☒ 1. TECHNICAL REPORT
☒ *Final* ☐ *Other (specify)*

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☐ 3. JOURNAL ARTICLE
a. TYPE: ☐ *Announcement Citation Only* ☐ *Preprint* ☐ *Postprint*
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H. Sponsoring DOE Program Office

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I. Subject Categories *(list primary one first)*

Makah

Keywords

Tribal, energy, renewable, wind, utility

J. Description/Abstract

This two year feasibility project was conducted to determine if the Makah reservation wind resource is viable for commercial generation and to investigate the viability and implementation of a tribal utility company capable of conducting energy business on the reservation.

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L. Recipient/Contractor Point of Contact *Contact for additional information (contact or organization name to be included in published citations and who would receive any external questions about the content of the STI Product or the research contained therein)*

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9/30/2003 *Thru* *9/30/2005*		Makah Nation
		Organization

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Tribal Renewable Energy - Final Report

Project Title: "Next Steps to Implement Renewable Energy Project on the Makah Indian Nation for the Pacific North West Region"

Covering Period: September 30, 2003 to September 30, 2005

Date of Report: May 16, 2006

Recipient Organization: Makah Indian Nation

Award Number: DE-FG36-03GO13124

Partners: Makah Indian Nation - No Partners

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1 Executive Summary:

This is the final report of the two year feasibility project conducted to determine if the Makah reservation wind resource is viable for commercial generation and to investigate the viability and implementation of a tribal utility company capable of conducting energy business on the reservation.

Over the 20 to 25 years leading up to this work, the Makah reservation in northwestern Washington had been the focus of much speculation with regard to potential wind power development. A number of commercial wind developers had proposed developments to the tribe and several had actually installed wind data collection equipment. The discussions and data collection did not produce any actual value to the tribe, nor were the resource assessment and data collection results shared with the tribe.

The goal of this work was to investigate the feasibility of generation from wind (or another source) and to parallel this work with the development of a tribal utility organization capable of undertaking joint ventures and materially participating in utility business and projects on the Makah reservation.

Sets of wind data were gathered at two tower locations on the reservation. The data were compared and combined with historical wind data, and processed under several wind energy assessment models to determine the output performance and the project economics of wind plants at the site. Preliminary transmission studies and project integration discussions were conducted with Clallam County PUD, the local utility and with BPA.

Analysis of the wind data and subsequent project modeling revealed that the Makah resource was not of sufficient capacity to support the required economics of commercial wind development. The limitations of the transmission system on the Olympic Peninsula further discourage generation development and the export of power from the site.

Once it was determined that commercial wind energy was most likely not feasible, a review of small wind generation and other self generation was conducted. Results indicate that there is feasibility for a small wind generation project constructed on Cougar Hill, adjacent to new load planned for the Neah Bay area.

The table below shows the capacity factors determined for several commercial turbines at the site.

Table 1 Capacity factors determined for several commercial turbines at the site

Wind energy: **2,956 kWh/m2**						
Mean wind speed: **6.3 m/s**						
WTG type	**Type**	**Power** [kW]	**Diam.** [m]	**Height** [m]	**Mean wind speed** [m/s]	**Capacity Factor** [%]
GE Wind Energy	GE 1.5sle	1,500	77.0	80.0	6.5	**29.7**
GE Wind Energy	GE 2.7	2,700	84.0	70.0	6.5	**22.0**
Suzlon	S 88	2,100	88.0	80.0	6.5	**28.1**

In spite of the low annual capacity factor, the Makah resource does have prominent winter peaking characteristics and may yet provide opportunities for limited self-generation on a strictly winter peaking generation schedule, perhaps in tandem with another form of generation.

Bio-gasification was explored as a potential generation source, but was determined not to be feasible and to have limited applicability due to lack of local feedstock supply and delivery logistics problems.

The second main area of work was to develop a sustainable tribal utility business structure based on accurate cost of service analysis and integrated resource planning.

A cooperative strategy was developed and discussed with the Clallam County PUD under which the Makah Energy Enterprise could be phased in over time, beginning first as a service provider to the PUD and eventually taking over ownership and operation of the distribution system.

A charter was drafted, reviewed, revised and finalized for a tribally owned utility capable of power purchase and distribution. The structure of the charter was based upon an existing Makah enterprise. The charter is awaiting execution by the Makah Tribal Council.

Under this work the following conclusions were determined:

1. Measured and historical wind data indicate that the Makah wind resource is not sufficient to support commercial wind generation.
2. Bio-gasification as an alternate source of local self generation has limited feasibility due to limited on-site feedstock and logistical difficulties in delivery of feedstock from external sources.
3. A single 2.1 MW wind turbine project was modeled and shown to be feasible; constructed on Cougar Hill near new load development in Neah Bay.

4. The Makah Energy Enterprise would be self-sustaining and profitable as a billing agency, through economic power purchase and through electric distribution system ownership and operations.
5. Any further work will follow the Makah Tribal Council's determination of the politically correct next steps in the development of the Makah Energy Enterprise and in implementation of any of the strategies developed under this project.

2 Comparison of Actual Accomplishments to Project Goals and Objectives:

The goals of the project were specified as follows:

a. Create a tribal utility organization capable of materially participating in a commercial utility venture on Makah lands.
b. Accomplish marketing, transmission, data analysis, environmental review and other required tasks to finalize commercial wind generation project feasibility work.
c. Position the Makah Utility Authority and its business partners to begin construction of a self-generation power plant.

The actual accomplishments of the project were in line with the projected goals as far as development of a local tribal utility business was concerned. A business structure and development plan was created whereby the Makah could create and operate a tribal utility business on the reservation that would operate commercially and would be in a position to finance projects and asset acquisitions.

The feasibility and development of a commercial wind plant proved to be not feasible and, as such the project goals specifically hinged to commercial wind generation were necessarily shifted toward investigation of alternate sources of generation. It was shown that small scale wind generation may be feasible.

3 Project Activities For Period Of Funding

3.1 Summary

Project activities revolved around the analysis and investigation of the generation and utility business potential of the Makah reservation. The work was accomplished by project technical consultants, Martin H. Wilde, of Coyote Energy in Columbia Falls, MT and James F. Yockey, of URS in Madison, WI. Wilde and Yockey worked to collect, reduce and analyze data to accomplish the project goals.

Analysis of wind data was used to predict the output of several wind plant models. Following the early determination that the wind resource was low capacity, investigations were conducted into bio-gasification as an alternate source of generation and plants were modeled in the Makah region. BPA was contacted and projects were proposed to them for limited generation on the Makah under the non-wires solutions initiative, one a small winter peaking wind plant and the other a 1MW bio-gasification generator.

An inventory and assessment of all distribution assets on the reservation was conducted and integrated with transmission and energy price data into a cost of service model for the reservation. A data base interface was constructed to be populated with local customer information and used in the tribes' utility business.

Significant time was involved in travel and in meeting on the reservation with tribal council members and with tribal planners to review goals, findings and project strategies. Wilde and Yockey provided presentations of findings, answered questions and carried out the wishes of tribal decision makers.

3.2 Progress in Q4-2003

3.2.1 Objective 1 - Formation of the utility authority

3.2.1.1 Identify retail loads

This process involved identification of the meters that served by the Utility. We concentrated on loads that fell within legally uncontested areas such as trust land for the initial evaluation. Utility bills were analyzed, quantified and aggregated and compared to the local utility tariffs.

The team met with the Clallam County PUD in Port Angeles, WA on 11/14/03. Present at the meeting from Clallam PUD were Dennis Bickford, General Manager, Fred Mitchell, Asst Manager, Ken Morgan, Transmission and Substation operator. Others in attendance included Shannon Greene, BPA Tribal Rep., Al Ingram, BPA renewables and Paul Fiedler, BPA, PBL rep.

The Makah team presented the project and obtained general information relating to substation and aggregate capacity serving the Makah reservation. A request submitted to Ken Morgan and Fred Mitchell for detailed data on Tribal loads.

3.2.1.2 Purchase of license, begin dBase construction

The license for the database was purchased by the Makah on 12/31/ 04. The database will serve as the main Tribal customer service and billing resource. Service address, billing address and customer contact information will be entered, as will billing class and other relevant information.

In the original design of the database there were plans to include some links to community activities. The Makah expressed a desire to use the web based database to also function as an internet portal.

For the database itself a structure was been completed and as soon as load information is received it will be integrated into the load information tables.

A formal request to Clallam County PUD for rates was initiated in order to begin a cost of service analysis.

3.2.1.3 Investigate purchased power prices with wholesale providers

We have been engaged in several conversations with BPA and Puget regarding power supply on the peninsula and the applicability and appetite for wind power. As of this writing we have general interest from power companies.

3.2.2 Objective 2 - Wind data analysis, Economics/Pricing Studies

3.2.2.1 Map existing wind data sites

3.2.2.2 Perform Quality Assurance of wind data

3.2.2.3 Determine Wind Shear

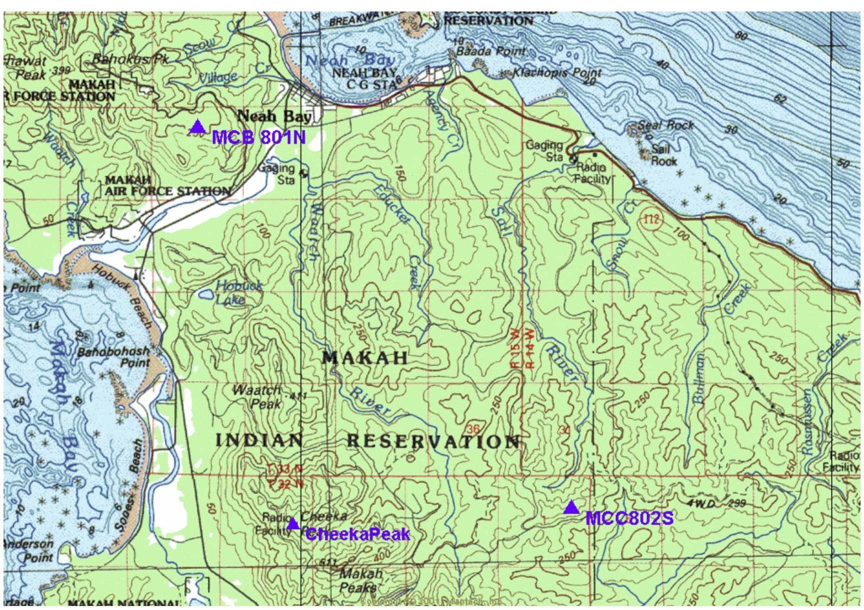
3.2.2.4 Correlate with long term reference data

3.2.2.5 Wind data analysis

3.2.2.6 Determine Output

3.2.2.7 Estimate production

Due to the late start of the work on the 2002 Makah DOE met tower project, data collection from the installed towers did not begin until late July of 2003. As of this writing, we have seen data from one site from July 23 through November 6 of 2003. We will postpone thorough wind data analysis of the two towers from DOE 2002, to sometime in Q2 or Q3 of 2004. The map below shows the location of the two towers.

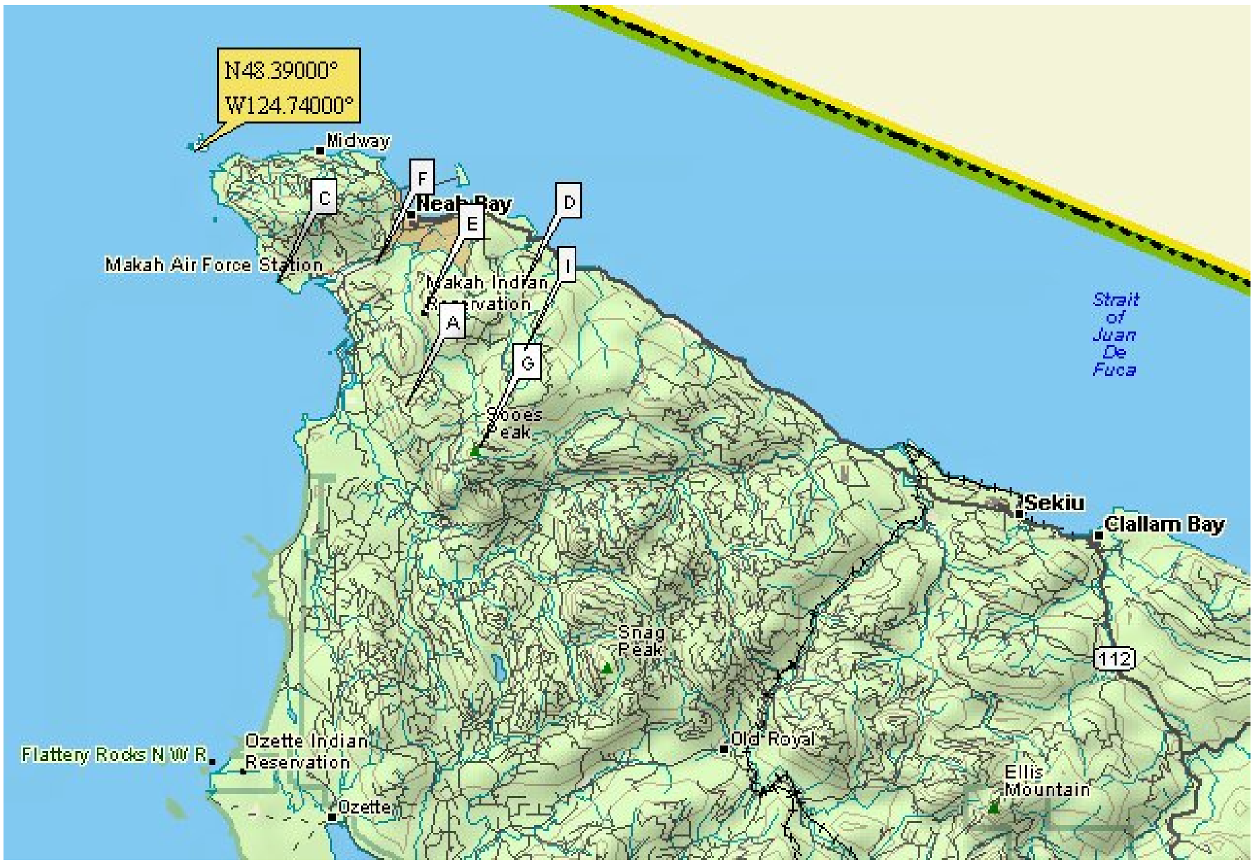


Site 801N (MCB) is an NRG 40M tower and site 802S (MCC) is an NRG 50M tower.

Historical wind data analysis

Due to the delay in the site specific site data acquisition, we have been limited to data analysis of historical data and general referencing of this data to the small amount of data available from the 50 M tower.

Analysis has been conducted using data from Tatoosh Island NOAA station. The station is owned and maintained by National Data Buoy Center and is located just off the northwestern tip of the Olympic Peninsula (48°23'30" N 124°44'06" W) as shown by the yellow coordinate box in the map below.



Tatoosh Island has been purchased by the Makah and provides a good regional source of historical wind data that is publicly available at: http://www.ndbc.noaa.gov/

Complete data sets were obtained for the years 1998, 1999 and 2000 and imported into Excel. The data were inspected for quality and observed to have data recovery rates for wind speed, of 93.73%, 98.74% and 98.99% respectively. The annual average wind speeds were 14.49 mph, 15.15 mph and 13.75 mph respectively.

Site info - Tatoosh Island NOAA station	
Site elevation	30.8 m above mean sea level
Air temp height:	15.5 m above site elevation

Anemometer height	25.3 m above site elevation		
Year	**1998**	**1999**	**2000**
Annual Average Wind Speeds	14.49	15.15	13.75
Data recovery rate	93.73%	98.74%	98.99%

The sea level data was transposed to a height of 300 Meters using the European model for wind shear taking into account the "roughness length" of the surrounding topography. The model provides a bracket for predicting the wind speeds at the 1000 foot elevation of the Makah ridges.

The following formula was used with a high-low bracket of roughness lengths to give a general idea of what we may expect at the elevation of the ridge tops. The wind speed at a certain height above ground level is given by:

$$v = v_{ref} \ln (z/z_0)/\ln (z_{ref}/z_0)$$

Where: **v** = wind speed at height z above ground level.
v_{ref} = reference speed, i.e. a wind speed we already know at height z ref .
ln is the natural logarithm function.
z = height above ground level for the desired velocity, v.
z_0= roughness length in the current wind direction.
(Roughness lengths may be found in the Chart below).
z_{ref} = reference height, i.e. the height where we know the exact wind speed v ref

Roughness Classes and Roughness Length Table

Rough-ness Class	Roughness Length m	Energy Index (per cent)	Landscape Type
0	0.0002	100	Water surface
0.5	0.0024	73	Completely open terrain with a smooth surface, e.g. concrete runways in airports, mowed grass, etc.
1	0.03	52	Open agricultural area without fences and hedgerows and very scattered buildings. Only softly rounded hills
1.5	0.055	45	Agricultural land with some houses and 8 meter tall sheltering hedgerows with a distance of approx. 1250 meters

2	0.1	39	Agricultural land with some houses and 8 meter tall sheltering hedgerows with a distance of approx. 500 meters
2.5	0.2	31	Agricultural land with many houses, shrubs and plants, or 8 meter tall sheltering hedgerows with a distance of approx. 250 meters
3	0.4	24	Villages, small towns, agricultural land with many or tall sheltering hedgerows, forests and very rough and uneven terrain
3.5	0.8	18	Larger cities with tall buildings
4	1.6	13	Very large cities with tall buildings and skyscrapers
Definitions according to the European Wind Atlas, WAsP. For practical examples, see the Guided Tour section on Wind Speed Calculation.			

Wind speed brackets were predicted based upon likely roughness lengths; smooth water (roughness length of 0.0002) at the lower end of the wind shear bracket and, open agricultural area (roughness length of 0.03) at the upper end of the bracket.

Wind Speeds (MPH)				
Year	Height (M)	**Measured** Wind Speed (MPH)	**Predicted** WS @ 300M Roughness length	
			0.0002	0.03
1998	25.3	14.49		
1998	300		17.54	19.80
1999	25.3	15.15		
1999	300		18.34	20.71
2000	25.3	13.75		
2000	300		16.65	18.80

This analysis predicts wind speeds for an elevation of 300 Meters ranging from a low of 16.65 MPH Class 4 “Good”) to a high of 20.71 MPH (Class 7 “superb”). The predicted range is essentially “reasonable” to “excellent”, but can be used only as a general predictor of the wind resource on the Makah.

Although the Tatoosh data is somewhat encouraging, we expect significant additional vertical component to the ridge top winds resulting from the steep upward slopes. The horizontal resultant wind speeds at the top of the ridges will be determined accurately upon collection of more site specific data.

Collected wind data from the 801N (MCB) tower was coordinated and compared to the Tatoosh Island data for the appropriate dates in 2003 (the Tatoosh data set was missing measurements for over a month during the 7/23 – 11/6 period).

The data seem to be poorly correlated; often there was wind at Tatoosh an none at the 40 meter tower (MCB) site. This suggests that topography may be a significant and dominating factor when comparing the Tatoosh historical data sets and the ridge top data collected on site and further, that there may be winds that flow through the Straight of San Juan de Fuca that are not evident on the nearby ridge lines.

Wind Speed versus Air Temp

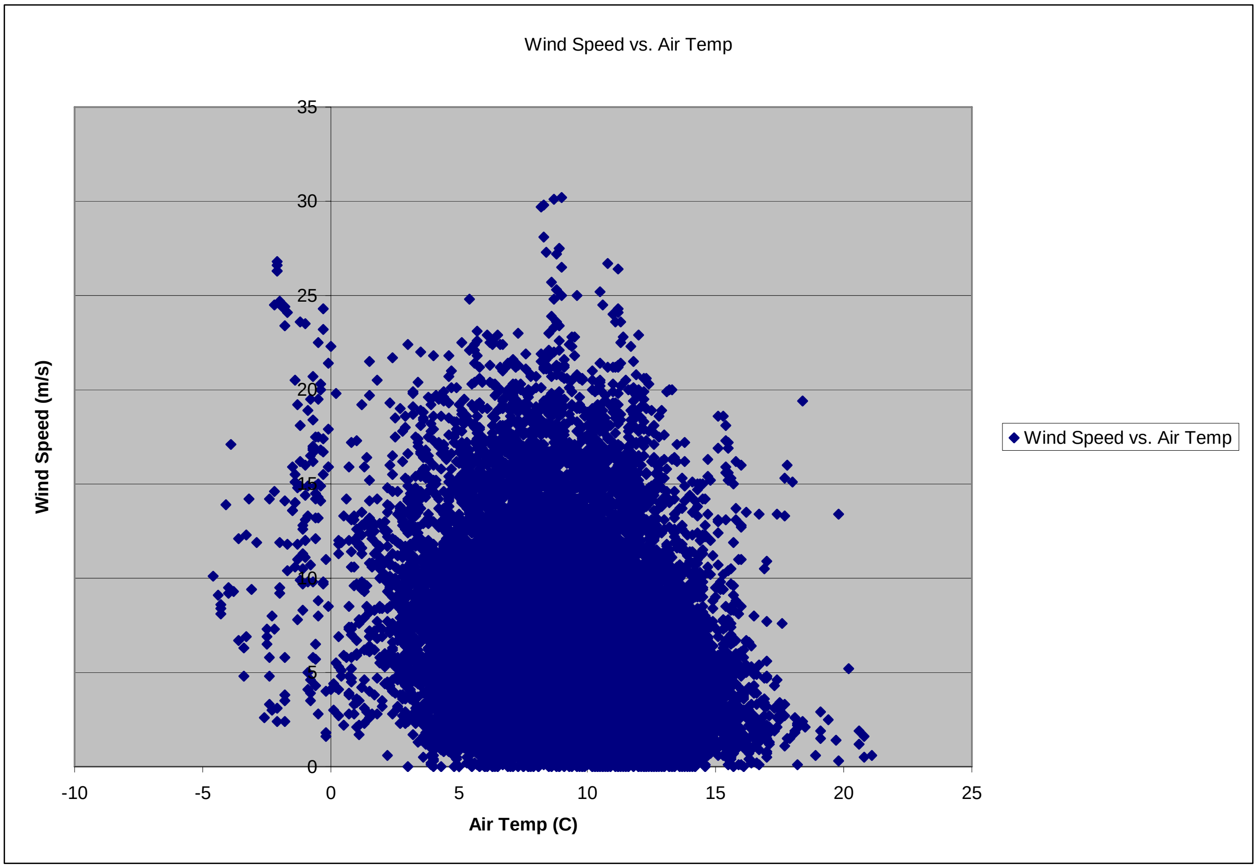
Although wind data analysis was only conducted at a general level during the presently reported quarter, we have conducted special wind data analysis in response to discussions with Bonneville Power Administration, Transmission Business Line (BPA), regarding inclusion of the Makah site in their plans for "non-wires solutions" for the Olympic Peninsula.

We would like BPA to consider funding the installation of some capacity of wind power on the Makah, which would assist in offsetting energy demands which are created by falling temperatures in the winter months.

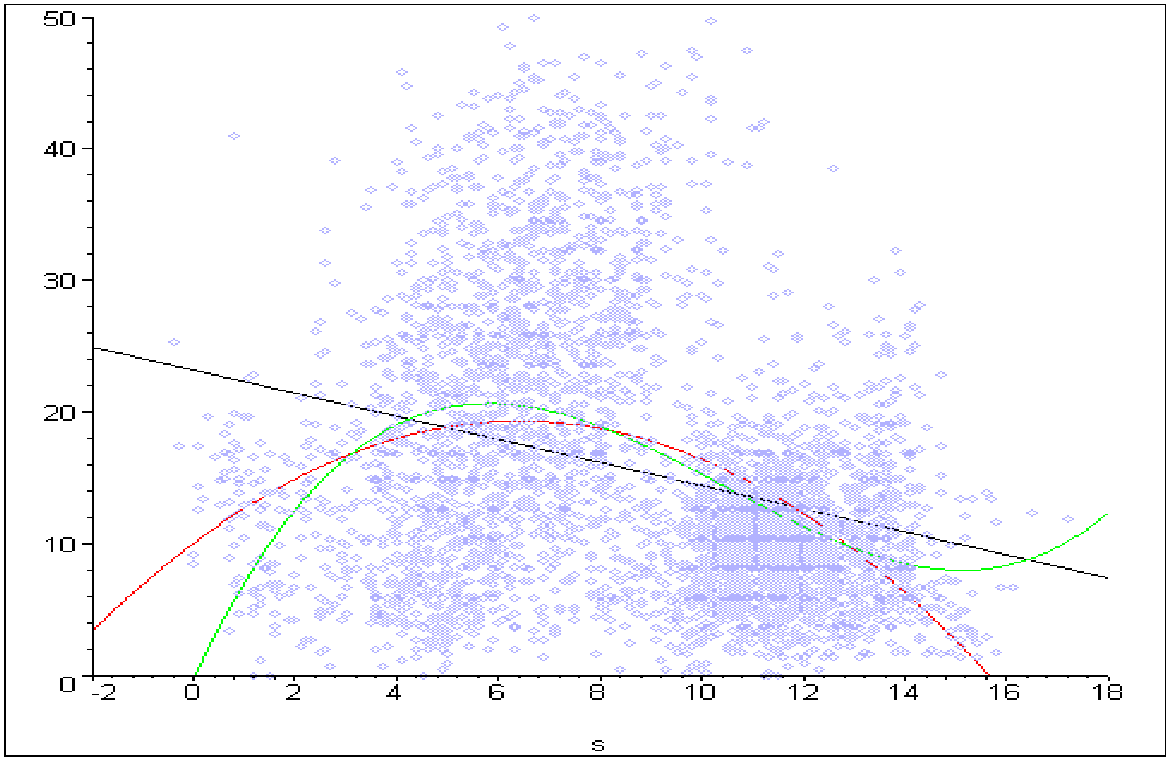
David Le, Program Manager at BPA explained that the peninsula under goes power shortages during times of falling temperatures in the winter months. The Makah resource is a winter peaking resource and may be suitable for this application.

Le encouraged Wilde to review existing historical wind and temperature data to determine if there exists a correlation between Makah regional wind speed and falling temperatures on the Olympic Peninsula.

A plot of the Tatoosh Island data for 2001 is shown below and shows the winter peaking character of the Makah region, where the winter months tend to couple higher wind speeds with lower temperatures.



The plot below groups three winter months and three summer months; December, January and February, 2000-2001 and June, July and August, 2001, and illustrates the seasonal character of the resource.



Occurrence: December, 2000, January - February and June – August, 2001
Location: Station TTIW1 - Tatoosh Island, WA
Horizontal Axis: Temperature in degrees Celsius. Domain: [-2, 18]
Vertical Axis: Wind Speed in Miles per Hour: Range: [0, 50]
Average Temperature: 8.8
Average Wind Speed: 15.4
Standard Deviation – Temperature: 3.4
Standard Deviation – Wind Speed: 10.2
Regression Analysis: $\mathbf{x}^3$
Linear $\{\mathbf{y} = -0.8776176495\,\mathbf{x} + 23.19096430\}$ *Black*
Quadratic $\{\mathbf{y} = -0.2262368589\,\mathbf{x}^2 + 2.901062348\,\mathbf{x} + 10.02716037\}$ *Red*
Cubic $\{\mathbf{y} = 0.03139643879\,\mathbf{x}^3 - 0.9856512045\,\mathbf{x}^2 + 8.271253429\,\mathbf{x} - 0.2702551843\}$ *Green*

Numerical analysis was conducted to explore the correlation between temperature and wind speed. Tatoosh data for 1998, 1999 and 2000 were used to examine hourly variations in temperature and wind speed and to look for degree of occurrence of the case where: temp was falling and wind speed was remaining constant or increasing.

It was determined that for the hourly data examined, the above case was true 24.26% of the time in 1998, 22.76% in 1999 and 22.61% in 2000. These results have been discussed with BPA and may lead to further investigation in the coming two quarters.

3.3 <u>Objective 4 - Environmental Profile and Mitigation Strategy</u>

3.3.1 Environmental Profile

No work was conducted on this task during the first quarter.

3.4 Progress in Q1-2004

3.4.1 Summary

Work has been conducted this quarter in areas of development of the tribal utility and in the assessment of the Makah wind resource. Much of the more detailed work in the development of a wind plant has been postponed while data are collected from the two 50 M met towers installed under 2002 Makah-DOE. Nine months of data are available as of this writing and the results and implications are discussed below.

In light of the wait-and-see situation with regard to development of the wind resource, emphasis has been placed on the tasks of local load assessment, Utility formation and infrastructure development. Progress made on these tasks is detailed and discussed below by objective.

3.4.2 Objective 1 - Formation of the utility authority

3.4.2.1 Identify distribution assets

A visit is scheduled for the week of May 17, during which time distribution assets will be identified and mapped and assessment begun.

3.4.2.2 Identify Retail Loads

In the last quarterly report we were awaiting data from the Clallam County PUD on substation and load data. Unfortunately only aggregate data was available. We have supplemented the aggregate data with monthly loads for 2 years.

The average aggregate load over the two years by service level is summarized in the table below.

Schedules and Meters:		% of total	Annual usage
E452	Residential Single phase (579 meters)	45.1%	7,543,331
E462	Residential 3 phase (1 meters)	0.2%	28,801
E401	Commercial Single phase (86 meters)	10.0%	1,679,420
E411	Commercial 3 phase (26 meters)	5.8%	964,217
E521	Commercial Large Power 3 phase (13 meters)	31.6%	5,281,020
E601	School Service single phase (5 meters)	0.6%	99,471
E603	School Service 3 phase (5 meters)	6.7%	1,126,616
			16,722,876

Aggregate and monthly data allows us to see the minimum load requirements for service to the Makah reservation however it is not sufficient for developing load profiles for wholesale service. Hourly meter readings, obtained daily, are generally considered the ideal data to support the transactions among wholesale providers and the retail sellers of energy.

In order for the Makah to create a tribal utility, more detailed information would be necessary. The hourly data that does exist resides on only 18 meters. Since there is no hourly data for most of the customers other methods had to be deployed to generate a representative view of the load for the various customer classes.

Accordingly, proxies for actual hourly metering will be produced for the large number of customers who do not have (and will not have for several years, if ever) hourly metering. The most common proxy for hourly metering is *profiling.*

3.4.2.3 Load Profiling Background

Load profiling uses average hourly consumption patterns as a proxy for individually metered customer data. Load profiling is the means by which each electric customer is allocated a portion of the hourly system loads, if that customer does not have hourly loads directly metered. Hourly demands can then be aggregated for each supplier, and multiplied by the hourly price to determine that supplier's cost contribution.

Currently, several approaches to load profiling are being used including static load profiling, dynamic modeling and dynamic load profiling. The choice of the most appropriate load profiling method for any situation depends on a great number of factors including cost, data availability, equipment availability, accuracy requirements, regulatory requirements and the needs of the utility distribution company. A discussion of these general methods follows.

Static load profiling is based on historical load research data that are usually differentiated by season, month and day. These load profiles are used as a proxy for a customer's current load shape. A major issue with this technique is its lack of a weather adjustment mechanism. Weather differences from the historical period to the current load profiling time frame are not considered. Weather is a significant determinant of a customer's demand and energy usage, and ultimately their load profile. Dynamic modeling makes use of historical load shapes but incorporates a weather response function into the profiling method. Statistical techniques have been developed to account for weather changes either on a daily or hourly basis.

The third general method, dynamic load profiling, requires that load research sample meters be read, data validated and load profiles produced daily. This approach is essentially a "real-time" construction of a customer segment's load shape. This technique captures all of the current factors that drive the shape of a load profile, but at a substantial increase in equipment and processing costs. Load research meters would have to be remotely monitored. Automated systems would be required to translate and validate the resulting load data on a real-time basis. A significant amount of time would be needed for the development of such systems, equipment and processes, including complex systems to identify and correct erroneous data on a real-time basis.

Profiling has important limitations, but nonetheless may be optimal for certain customers indefinitely. Limitations include:

- Provides no incentive or mechanism to customers to respond to short term market forces, forgoing major economic benefits of open access.

- Embodies unavoidable inaccuracies by its averaging of customer behaviors. Some customers will pay more, others less, than they would pay if they had hourly metering.
- Introduces inaccuracies into the settlement process, which increases financial risk for energy marketers serving small customers.
- Provides very limited data to support new or alternative rate structures, such as time-of-use, load control or more innovative rates.

Our approach was to use a modified static profiling approach. The steps used in this approach are as follows:

Step 1:
Group load research meter data based on season and day-type combination
The load data is grouped into 12 months with 2 day types for each profile group. Holidays are put into the included with weekends.

Example:
12 Season (month) 2 Day-Type Calendar

Season 1 (January)	Season 7 (July)
Season 2 (February)	Season 8 (August)
Season 3 (March)	Season 9 (September)
Season 4 (April)	Season 10 (October)
Season 5 (May)	Season 11 (November)
Season 6 (June)	Season 12 (December)

Day Type 1 (Weekday): Mon, Tue, Wed, Thurs, Fri
Day Type 2 (Weekend): Sat, Sun, Holiday

Step 2:
Create a weighted average of all observations for the profile for each day.
Example:
Weights are assigned by the user within the software package:

Profile	Load Research Meter	Weight
Residential	R123	1
Residential	R456	1
Residential	R789	1

(Note: weights will reflect weights assigned to each meter in the sampling process)

Illustrative Observations from the meter:

Load Research Meter	Day	Hour1	Hour2	Hour3	Hour4 …
R123	12/1/04	30	50	40	60
R456	12/1/04	35	55	45	65
R789	12/1/04	40	60	50	70

Result:

Profile	Day	Hour1	Hour2	Hour3	Hour4 …

Residential	12/1/04	35	55	45	65
Residential	12/2/04	60	70	50	55
Residential	12/3/04	55	70	55	60
Residential	12/4/04	32	60	45	50

Step 3: Average the load values to create an Average Load Shape
Example:
Season (month) 12, Day-Type 1

Profile	Day	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	60	70	50	55
Residential	12/2/04	55	70	55	60
Residential	12/3/04	32	60	45	50

Result:

Profile	Day	Type	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	Weekday	45.5	63.75	48.75	57.5

Step 4:
Sort the load values in descending order to create a Load Duration Curve
Example:
Season 12, Day Type 1

Profile	Day	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	65	55	45	35
Residential	12/2/04	70	60	55	50
Residential	12/3/04	70	60	55	55
Residential	12/4/04	60	50	45	32

Step 5:
Average the Load Duration Curve values to create an Average Load Duration Curve
Example:
Result:

Profile	Day	Type	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	Weekday	66.25	56.25	50	43

Step 6:
Map the Average Load Duration Curve to the Average Load Shape
Example:
Average Load Shape:

Profile	Day	Type	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	Weekday	45.5	63.75	48.75	57.5

Average Load Duration Curve:

Profile	Day	Type	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	Weekday	66.25	56.25	50	43

Resulting Load Profile:

Profile	Day	Type	Hour1	Hour2	Hour3	Hour4 …
Residential	12/1/04	Weekday	43	66.25	50	56.25

The above illustrated methodology preserves the same usage pattern as a traditional static profiling approach (the average load shape shown above) but also preserves the level of peaks and troughs obtained through the average load duration curve. The result is a static profile that better represents a "typical day."

The following are load curves generated by the software for a typical residential day and a typical commercial day on the Makah. These curves will be used with task e. of Objective No. 1, where the load profile will be shopped to various suppliers incorporating self-generation possibilities.

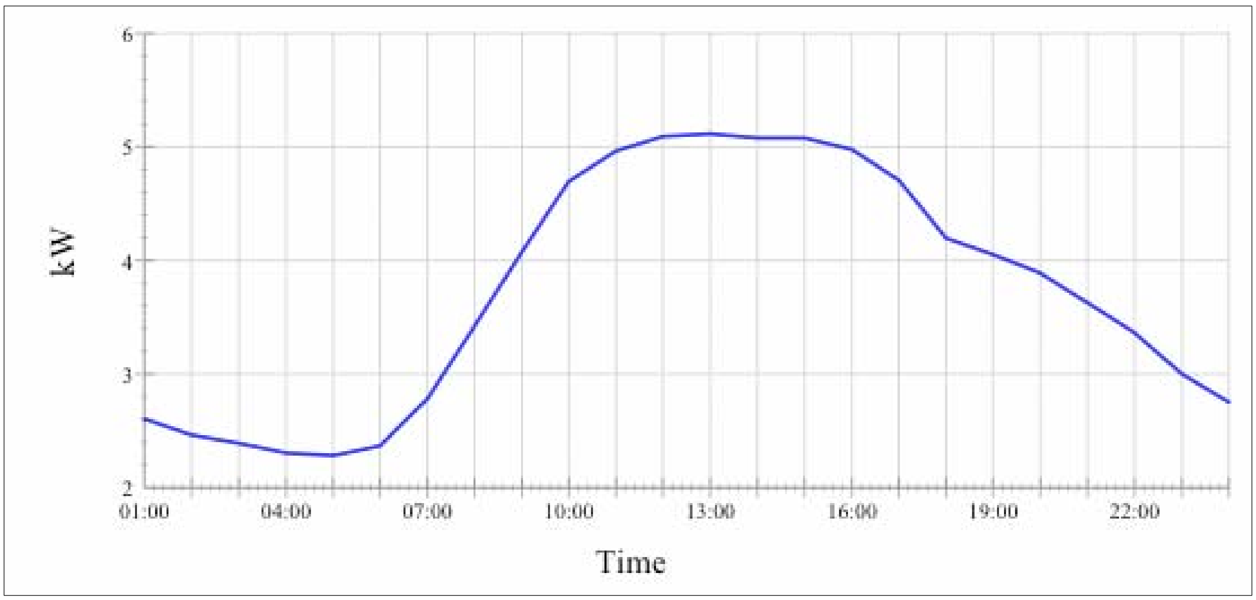


Figure 1 Load curve for typical day of commercial load on the Makah

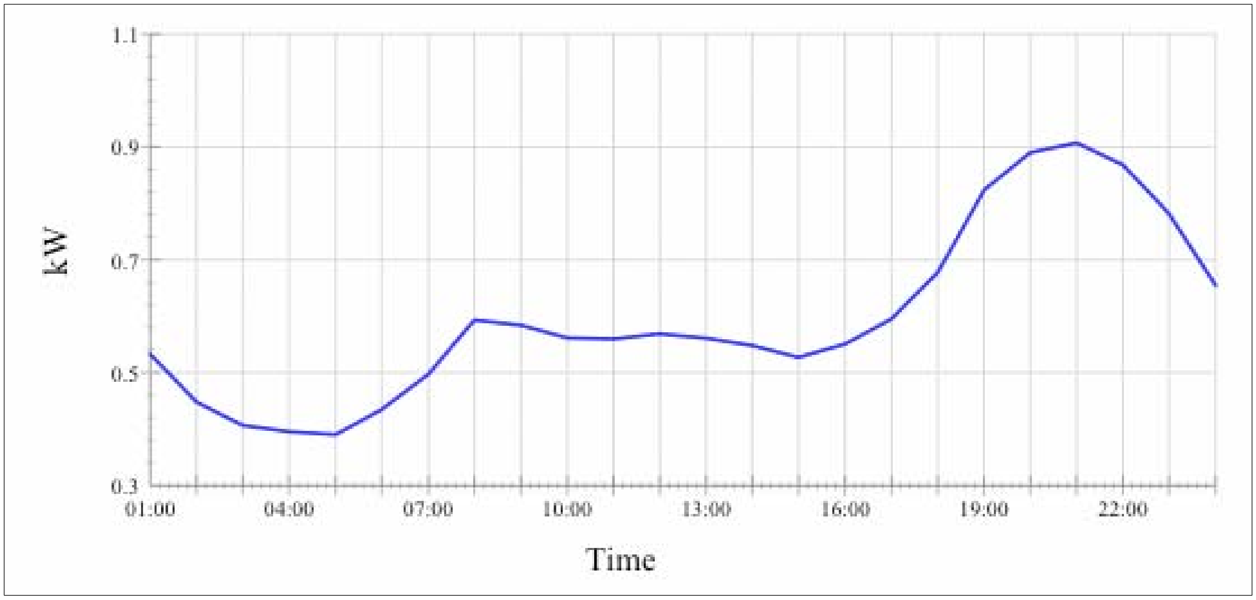


Figure 2 Load profile for typical day of residential load on the Makah

3.4.2.4 Database construction with Portal

The Makah Tribal leadership made a decision to incorporate the construction of an internet portal into the larger utility development project. This portal may be used as an interface for billing, meter reading and other utility functions. URS has gathered existing portal functionality and has begun to interview Tribal members who have been portal content providers in the past. A draft structure of the portal has been produced and will be demonstrated to Tribal members during the week of May 17 when the next visit is scheduled.

3.4.2.5 Appraisal of distribution assets

A visit is scheduled for the week of May 17.

3.4.3 Objective 2 - Wind data analysis, Economics/Pricing Studies

3.4.3.1 Use collected wind data and existing historical data sources to refine Makah resource assessment and to begin to predict economics of wind plant.

3.4.3.2 Interact with Karen Kronner to develop environmental permitting profile.

Data summaries have been compiled and were obtained from John Wade (DOE-Makah 2002). The data indicate that the average wind speed collected at the two towers on the reservation is around **15 mph at 40 M**. this average is over the nine month period of data collection to-date.

The value of the average wind speed was lower than we had hoped for and was compared to reference data to determine the annual variation and the extent to which this may have affected the data gathered this past year.

Analysis was conducted using multi-year data sets from the Tatoosh Island NOAA station and from the Quiliyute upper air station east of the Olympic Mountains. Tatoosh data sets span a period of 1994-2001 and the Quiliyute set were available for 1998-2004. The data for the past year were compared to other years to determine where the collected data fit with respect to the mean wind speed in the area.

John Wade's results indicate that the winds measured during the period of record are about 2% higher than what would be expected normally. October was an excellent month as our data also showed. August and November were poor and we experienced the same disappointing winds in those months. The 2004 winds have been closer to expected. The average speed for July through March at Quiliyute is 10% stronger than one would expect the annual mean on average. This data does not support any optimism for higher wind speeds at the Makah site in future years.

Analysis of the Tatoosh Island data shows that data collected at that location from July, 2003 through March, 2004 was slightly higher than the multi-year average for the period 1/1994 -12/2001 at the same location.

These results provide a fairly strong indicator that the wind resource on the Makah will likely be in the range of Class 3 to 4 as described by the NREL Wind Power Classification.

The impact of the lower average wind speed on wind energy development is further exacerbated by the fact that there are two separate and significant primary wind directions. This means that turbines would have to be spread out more to capture the energy from the varying directions. This lessens the likelihood of large commercial development on the Makah.

In light of the seemingly marginal wind speeds and the wind resource directional variability, we will be focusing future efforts on defining a small wind project which might serve the local loads and which may provide transmission relief to the local supply. It may be that favorable economics can be achieved by reducing transmission and load demand. Also the installation of two to four machines will allow flexibility in siting and more readily accommodate the environmental factors assumed to be present in the region.

We are hoping to provide at least a small project under BPA's non-wires solutions initiative. We will investigate this and other available funding sources for a small installation during the next several quarters.

In addition to determining the available possibilities for wind energy we will consider biomass and other renewable fuel sources. One possibility may be pyrolysis of bio-mass or other organics into hydrogen and carbon product.

<u>Environmental review.</u>

The preliminary review by biologist, Karen Kronner of Northwest Wildlife Consultants was obtained. Kronner reviewed the two Met tower locations and concluded that, given several months of wind data collection it would be more reasonable to know more about which sites if any are looking promising for wind power development. She anticipates that is at that point when we would launch a more thorough review of the potential biological concerns.

3.5 Progress in Q2-2004

3.5.1 Objective 1 - Formation of the utility authority

Wilde and Yockey traveled to Neah Bay on May 18th to meet with the rest of the Makah-DOE team and the Makah Tribal council. The trip was also intended for Yockey and Wilde to conduct on-the-ground identification of distribution assets.

The meeting agenda introduced the project and progress to-date to newly elected council members and the new CEO of the tribe. The goals of the project were laid-out and the findings to date were summarized.

The next day, Wilde and Yockey drove the reservation identifying and counting the existing distribution system assets to enable an appraisal and estimate the buy out value.

3.5.1.1 Identify distribution assets

The substation serving the Makah load was identified, photographed and nameplate data gathered. In addition, a pole count was conducted tracing the distribution circuits throughout the reservation.

The substation is located on the corner of Young Doctor and Back Track road. There are three circuits identified as “A”, “B”, and “C” that extend from the substation and provide electric service to the town and region.

A CAD drawing of the utility assets (provided by Clallam County PUD) serving the reservation was used as a reference document to identify all assets and is included as Figure 3.

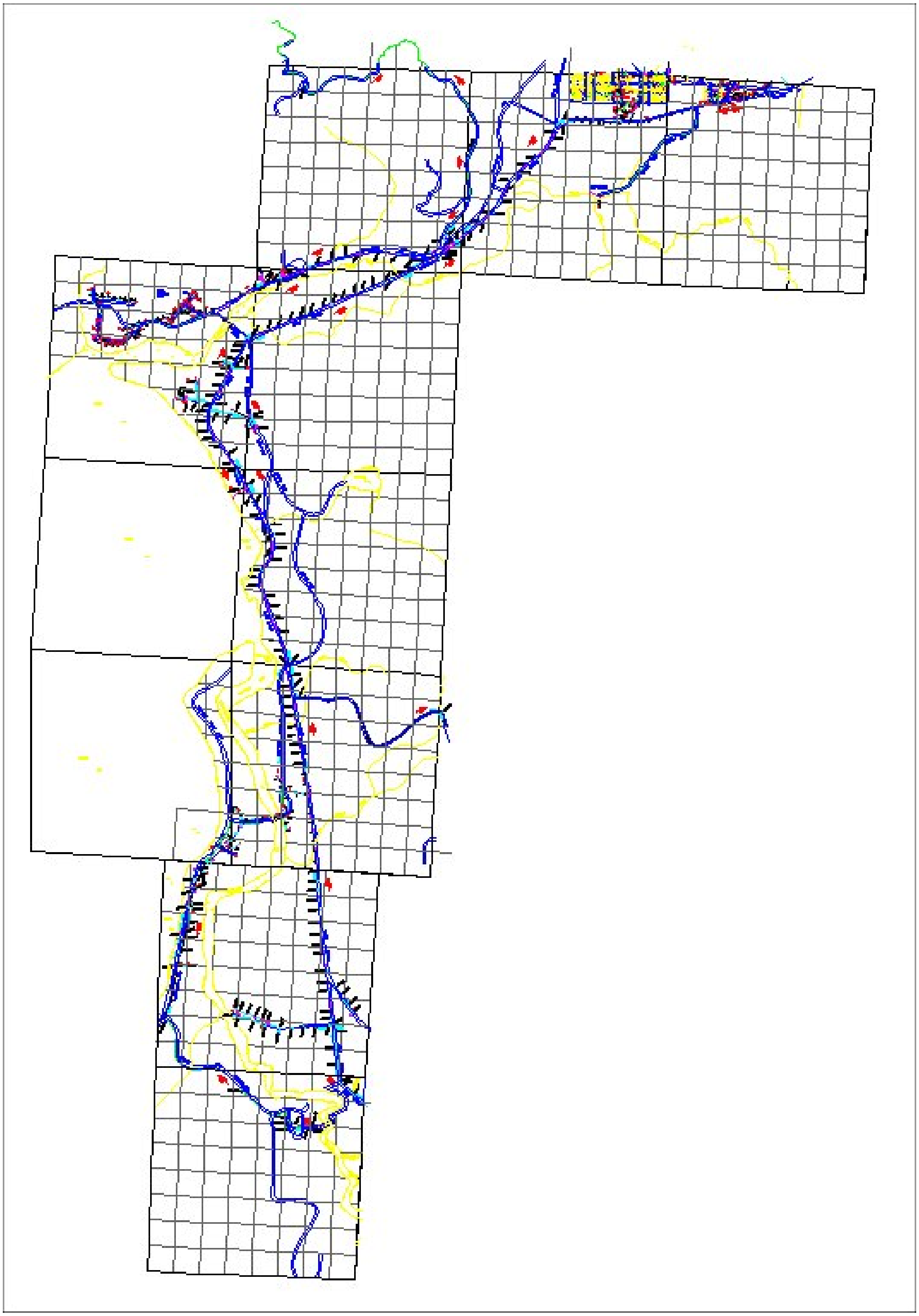


Figure 3 - CAD drawing of Makah distribution system from Clallam County PUD

There are some minor discrepancies between the field inventory and the CAD drawing that are presently being reconciled, but for purposes of initial discussion, we have summarized the assets in the following table.

Equipment Description	# of units
7.5 MVA Standard of Warren transformer 67000 – 13200/7620	1
333 kVA regulator	3
Circuit A poles	180
Circuit B poles	33
Circuit C poles	85
Pole mounted transformers	178
Pad mount transformers	6
Meters	715

3.5.1.2 Appraisal of distribution assets

In order to appraise the distribution assets, short of a full due diligence process that would be used under an actual purchase agreement or condemnation procedure, we used industry standard rules of thumb for replacement cost of distribution assets.

The appraisal method used is a replacement cost less depreciation method (RCLD) on the assets identified. Another method using original cost less depreciation would be used to reconcile the numbers and refine the offer to purchase should the Tribe decide to pursue purchase of the distribution assets. Using the RCLD it was assumed a transformer replacement cost at $10 per kVA and a pole cost of $1,500 per pole. The meter cost assumption is based on $250 per meter point, another industry rule of thumb for bulk purchase of revenue grade meters.

The substation was put in service, and the majority of the build out took place, in 1975. Therefore many of the assets have 29-year depreciation. However for to be conservative, this analysis used a 15 year depreciation to account for the fact that a number of items may have been replaced or been put into service since 1975.

It was decided that, an exhaustive itemization of each asset's lifecycle history would unnecessarily cost the Tribe money and time, that would be better spent as part of a full due diligence effort associated with a future buy/sale. Such a lifecycle inventory would also burden the incumbent utility provider right now and would strain the current cooperative relationship.

The following table of assumptions lists the inventoried assets with the applied RCLD method to come up with an estimated value of the distribution assets.

Assumptions for Makah Utilities							
7500 KVA Serial #PGF 1234 67,000V Delta to 13,200/7,620 Volts Gnd. Wye There is only one transformer, 7.5 MVA and three regulators, 333KVA each. The transformer appears purchased in 1962.							

Clallam County PUD							
Capital Costs							
		Original	Accumulated	Original Cost			
Description		Cost	Depreciation	less Depreciation			
	Acct. # 1						
	Acct. # 2						
	Acct. # 3						
	Acct. # 4						
	Acct. # 5						
	Acct. # 6						
	Acct. # 7						
	Acct. # 8						
	Acct. # 9						
Net Plant in Service							
		Replacement	Accumulated	Replacement Cost			
Description		Cost	Depreciation	less Depreciation		Depreciation	Accumulated
						30	15
7500 KVA Serial #PGF 1234	Acct. # 1	90,000	45,000	45,000		3,000	45,000
Three 333kVA regulators	Acct. # 2	12,000	6,000	6,000		400	6,000
300 Poles	Acct. # 3	450,000	225,000	225,000		15,000	225,000
178 polemount transformers	Acct. # 4	44,500	22,250	22,250		1,483	22,250
Six padmount transformers	Acct. # 5	30,000	15,000	15,000		1,000	15,000
715 meters	Acct. # 6	178,750	89,375	89,375		5,958	89,375
	Acct. # 7						
	Acct. # 8						
	Acct. # 9						
Net Plant in Service		805,250	402,625	402,625			
Deferred Taxes							
Regulatory Assets							
Transaction Costs							
Sales Price							
Miles of Line				3,132			
Consumers				6,926	2.2		
kWh sold				155,209,308			
Power Costs				5,530,127	0.0356		
Other Costs				4,257,519	0.0274		
COS				9,787,646			
COS per kWh				0.0631			

COS per customer				1,413			
COS per line mile				3,125			
Residential	49%	5087	5,158,160	80,838,857	0.0638		
Commercial	47%	1394	4,912,510	70,175,889	0.0700		
Seasonal	1%	412	77,006	635,427	0.1212		
other	3%	33	320,502	3,559,135	0.0901		
		6926	10,468,178	155,209,308			
	312,401	$ 61.41		0.0020	0.0618		
	297,524	$ 213.43		0.0019	0.0681		
	4,664	$ 11.32		0.0000	0.1212		
	19,411	$ 588.21		0.0001	0.0899		
Credits			634,000	0.0041			
Load Growth							
Current Load							
Month	Peak Demand	Load Factor	Days/month	kWh			
Jan	8,008	0.8520	31	5076175.104			
Feb	8,686	0.8067	28				
Mar	7,612	0.6138	31				
Apr	6,502	0.6391	30				
May	4,829	0.6484	31				
Jun	3,000	0.9067	30				
Jul	3,436	0.7742	31				
Aug	3,251	0.8140	31				
Sep	3,007	0.8050	30				
Oct	5,167	0.6300	31				
Nov	6,740	0.7764	30				
Dec	7,427	0.8620	31				

With an estimated cost-of-plant and the load information developed in Q1 of 2004 an interim cost of service analysis was developed.

The analysis compares the current cost of service shouldered by the Tribe and compares it to the cost of service based on purchase of the distribution assets, purchase of wholesale power from BPA and delivery costs based on debt service, operations and maintenance and administrative costs.

The comparison reveals that, under the assumption that the current plant in service is at least halfway depreciated a tribal utility could be cost competitive with the incumbent utility.

Makah - Electric Utility	
Cost of Service Analysis (in nominal dollars)	**BPA PF-02**

Annual and Five Year Savings Analysis (in nominal dollars)	Current load with no load growth	
Capital Cost		
Replacement cost less depreciation	$ 402,625	
Load		
PUD Supplied	16,722,876	
Purchased Power	-	
Self Generation	-	
	16,722,876	kWh
Retail Energy Rate		
Clallam County PUD (variable energy)	$ 0.0652	per kWh
Clallam County PUD (fixed plant)	$ 0.0056	per kWh
	$ 0.07076	
Wholesale Energy Rates BPA PBL		
Demand Charge	$ 0.00640	per kWh
HLH energy rate	$ 0.00929	per kWh
LLH energy rate	$ 0.01354	per kWh
Load variance rate	$ 0.00117	per kWh
Total Wholesale Cost	$ 0.03040	
MTU Delivery Costs		
Depreciation @ 2.75%	$ 0.00066	per kWh
debt @ 5% for 30 years	$ 0.00155	per kWh
O&M at 150,000 per year	$ 0.00897	per kWh
Administration at $250,000 per year	$ 0.01495	per kWh
Losses are nominal	$ -	per kWh
Cost of Delivery	$ 0.02613	per kWh
Total Delivered Cost/kWh to End Use		
Weighted wholesale plus cost of delivery	$ 0.05654	per kWh
Total Delivered Cost to End Use - Annual		
Current Average Rate	$ 1,183,275	
MTU Rate	$ 945,442	
First Year Savings by TMTU Compared to Staying with Current Supplier		
	$ 237,832	
Five Year Savings by TMTU Compared to Staying with Current Supplier		
	$ 1,189,161	

This is an interim cost of service analysis and more detailed work regarding the age and condition of existing plant needs to be done. For example, the substation is around 29 years old and may be likely to fail within the next 5 years. In this case a purchase of the sub may not make sense at the initial development of the utility. Instead a lease with a maintenance agreement may make more sense. These kinds of decisions would be made only after full due diligence associated with a purchase.

3.5.2 Objective 2 - Wind data analysis, Economics/Pricing Studies

Wind data analysis by John Wade and Wilde based upon the findings of the 2002 DOE feasibility study, showed the resource in the area to be marginal and largely unsuitable for commercial wind generation.

During the May meeting, the Makah tribal council and the project team discussed realistic limited wind generation applications in the Makah wind resource and applications using other power generation options which might be available to supplement purchased power.

A number of prototypical technologies were discussed. Among the alternates discussed were Bio-mass, wave energy and conversion of organic waste into hydrogen. Yockey described a pyrolysis process that he has been very excited about and has taken a personal interest in.

Yockey presented information on a commercial ready gasification process utilizing a method of pure pyrolysis. Pyrolysis is the process of thermal decomposition to produce gases, liquids (tar), and char (solid residue). These pyrolysis products can all be used as fuels, with or without prior upgrading, or they can be utilized as feedstock for chemical or material industries. The types of materials which are candidates for pyrolysis processing include coal, plant biomass, animal and human waste, food scraps, paper, cardboard, plastics, and rubber. Yockey has been following the commercialization and deployment of a specific commercial technology known as the McMullen process.

During the May meeting, the Makah group was enthusiastic that there are significant opportunities to intercept waste streams from Port Angeles and surrounding counties. The Makah council and business folks instructed the project team to evaluate and, as appropriate, pursue the Pyrolysis process as a green power alternative to the wind energy.

The council contributed the expertise of Steve Pendleton, the tribe's environmental manager, to assist the group in determination of a suitable source of feedstock for the pyrolysis process. The Makah Tribal planners and Pendleton will be meeting with Wilde and Yockey in late July to observe and investigate the McMullen method and report back to the Council regarding it's suitability for the Makah application.

Dave Somes, a Makah council member, committed to research the possibility of a supply of tires which may be plentiful as a feedstock.

The team hopes to design small project to meet local needs and submit it to the BPA non-wires solutions RFP during August, 2004

3.6 Progress in Q3-2004

3.6.1 Objective 1 - Formation of the utility authority

Significant steps were accomplished with regard to formation of the Makah tribal utility. These include a verification of the previously identified distribution utility assets with Clallam PUD, an important discussion with the PUD regarding first steps toward tribal ownership and utility function, the drafting and approval of the corporate tribal utilities charter and considerable detailed investigation of other self-generation options.

During the October meeting with council, the implementation status of the tribal utility charter was discussed. It is scheduled for immediate implementation and will be run in a fashion similar to the existing Makah Forestry business. Also discussed were the marginal results of the wind resource assessment and the alternate options for self generation including wave energy, bio-fuel and small wind, which could conceivably be coupled with purchased power to provide components of an overall portfolio to meet local needs.

3.6.1.1 Investigate purchase power prices

In the last quarterly report the team identified the BPA purchase power prices likely to be in effect for the tribal utility. These were incorporated into the interim cost of service analysis. A number of other assumptions were incorporated into the model with regard to the distribution price, based on the appraised value of the assets, personnel costs necessary to run the utility and assumptions of wheeling charge costs.

It has been determined that the previous assumptions around the wheeling charge will require more scrutiny in light of discussions held with Clallam PUD in early October. Specifically PUD indicated that the upgrades and repairs on the 69 kV radial line to the reservation would need to be recovered and could not be stranded if the tribe were to purchase the distribution assets. What this means in terms of an accurate cost per MWh is yet to be determined.

Clallam County PUD made clear it is their intent to provide an “open book” for the team’s future work in determination of the value and buy-out cost of the distribution system physical plant. This is good news as the tribe and the PUD will be able to come to consensus on the value of the assets and not simply rely on a singular opinion. These open records and maintenance agreements will be the basis of a refined final cost of service analysis.

3.6.1.2 Begin negotiations with local utility and RUS

On October 8th, Wilde, Yockey and Denney met with the managers and engineers at Clallam county PUD to discuss the Makah’s intent to become their own utility. With the independent (and conservative) estimate of the cost of service derived in advance, the team was in a position to approach Clallam PUD armed with knowledge of what it would cost to buy the existing distribution assets. This provided confidence for entering into negotiations. Confidence was further bolstered by the full support of the Tribal council and planning staff as evidenced by the creation and adoption of a tribal utility charter.

This discussion lasted several hours and included topics of, training of tribal lineman, the tribal utilities provision of billing agency and collections functions for the PUD, arranging for inspection of maintenance and purchase records of the physical plant and prepayment meters, among other topics. The candor shown by the PUD was appreciated and will serve as a positive basis for further fruitful discussions.

With regard to RUS, contacts have been initiated with the D.C. office. The PUD structure uses a different source of money than rural utilities. This difference should prove favorable toward Makah. Specifically, the cost of money and the amortization schedule should be more favorable since municipal funds which are available to PUD have 20 year time frames and funds to RUS are 30 years. Discussions have just begun however and will proceed over the next 2 quarters as planned for in the project schedule.

3.6.1.3 Complete database and integrate COS data into billing system

Broad meter data has been loaded into the database and a rates table created by meter type for utility billing purposes. The team is working with Clallam to get an electronic file with the addresses and names of all the accounts that can be imported into the database. So far Clallam has been helpful with providing data and the team will be able to incorporate this data into the database over this quarter. As the next steps are completed toward a final COS analysis the team will incorporate the information to create a final rate design to begin billing services. This task is significantly ahead of schedule.

3.6.2 Objective 2 - Wind data analysis, Economics/Pricing Studies

The 2002 DOE 12-month wind assessment has been completed. The final analysis of the data suggests a marginal annual wind resource, but significant capacity factor apparent during the five winter months.

3.6.2.1 Investigation of other self-generation options

The team has been engaged in the assessment of suitable forms of self generation that may lend themselves to a strategic portfolio of power options. Possibilities for self generation include small wind, bio-fuel, wave energy and others.

In late July, the team, along with Steve Pendleton of the Makah Environmental Office, met in Madison, WI to witness a demonstration of pre-commercial innovative bio-gasification technology. As a result of this interesting technology, the Makah Tribal Utility has submitted a proposal to the BPA “non-wires solutions RFP” during August, 2004 for a small bio-gas generation project to meet local needs. The team is excited to work with BPA to setup the project, and is awaiting BPA’s response to the concept proposal.

On October 7th, Wilde and Yockey visited Olympia, WA to meet with a company that has developed and constructed a proprietary system used for non-combustion cracking of organic waste into fractional components of gas, oil and solids. These techniques could be applicable for self-generation at the remote Makah site, whist offering high efficiency and green power solutions.

In prior discussions with BPA the prevalence of a winter peaking wind resource was valued (as discussed in previous quarterly reports). The team intends to investigate possible small wind installations under a winter peaking premium value.

Brief discussions were conducted with Aqua Energy, a company who has been investigating a proprietary system for wave energy in cooperation with the Makah. Aqua seems to be having financial difficulty and did not seem interested in working with the team on the present effort. Denny has initiated contact with Ocean Energy, another wave energy company, who will be contacted in the coming quarter regarding the development of a meaningful and reliable wave generation program.

3.7 Progress in Q4-2004

3.7.1 Summary

This report marks the halfway point in the work term. Over the first year it was determined that the wind resource was not as strong as has been believed. Other groups have measured the wind over the past ten years, but have not shared the data with the Makah, so the gathering of data, and the ownership of this data, has given the tribe the advantage of understanding the nature of the wind resource first hand.

The existing resource does show prominent winter peaking characteristics and may yet provide opportunities for limited self-generation on a strictly winter peaking generation schedule, perhaps in unison with another form of generation.

The development of tribal utility infrastructure was proposed as a necessary and required component of the investigation into self generation on the Makah lands. The council, planners and technical contractors (“the team”), have made great headway in the investigation and strategic planning of a utility business for the Makah. The utility organization is to be structured as an enterprise under the tribal council comparable to the existing Makah Forestry Enterprise. The enterprise will be setup to plan, finance and operate utility services and physical plants.

The lackluster results of the wind resource assessment motivated the team to investigate other forms of self-generation, stressing clean renewable technologies such as bio-mass, waste recycling and wave generation. The team also investigated the business and engineering aspects of acquisition and operation of the local distribution system by the tribal utility enterprise.

Work was accomplished in the last quarter of 2004, both with regard to formation of the tribal utility and, in refinement of available self generation options, in areas of:

- verification and identification of utility assets with Clallam PUD
- meeting with the PUD regarding first steps toward tribal ownership and utility function
- drafting of the charter, and first and second legal review, of the Makah tribal

utility enterprise.

- steps in the on-going investigation of self-generation options.

3.7.2 Objective 1 - Formation of the utility authority

3.7.2.1 Negotiations with local utility and RUS

On October 8th the team met with Clallam County PUD and discussed the Makah's intent to create a tribal utility. The discussion lasted several hours and included discussion on, the training of a Neah Bay based tribal lineman, the tribal utility providing a billing agency service and collections for the PUD, arranging for inspection of maintenance and purchase records of the physical plant and prepayment meters and a several other topics. The positive attitude, candor and desire to be cooperative put forth by the PUD was notable and will serve as a solid basis for future discussions.

The team approached the meeting with Clallam PUD armed with a reasonable knowledge of what it would cost to buy the existing distribution assets. This knowledge was the result of prior work to develop an estimate for the cost of service and provided confidence and intelligence for entering into preliminary negotiations. The team's confidence was further bolstered by the full support of the Tribal council and planning staff as evidenced by the decision to create and charter the new tribal utility enterprise.

Initial points of contact were determined for RUS in anticipation of a funding proposal for purchase of distribution and billing hardware and for funding self-generation plants. We believe the PUD structure uses a different source of money than rural utilities and this difference should prove favorable toward Makah. Specifically, the cost of money and the amortization schedule should be more favorable since the municipal funds available to PUD have 20 year time frames and funds available under RUS have 30 year payment terms.

Financing discussions are just in the beginning stages and will proceed over the next 3 quarters, as the budget estimates for distribution system purchase, and the scope and budgets for self-generation, are further refined.

3.7.2.2 Investigate purchase power prices

The assumptions made last quarter in the "interim cost of service analysis" for wheeling charges, were reassessed this quarter in the aftermath of discussions held with Clallam PUD in early October. Specifically, the PUD indicated that recent upgrades and repairs on the 69 kV radial line serving the reservation would need to be recovered and not stranded if the tribe were to purchase the distribution assets. The direct impact of these costs will be determined more closely through assessment, review and valuation work to be accomplished in the coming quarter.

Clallam PUD indicated their intention to provide open books to assist the Makah in understanding the cost basis of the distribution system physical plant and the cost of operations and maintenance. This offer by the PUD is very favorable to the tribal utility venture, in that the Makah and the PUD will be able to come to clear consensus on the value of the assets under the present work and not simply rely on the team's estimates or the PUD's own opinion.

Examination of the PUD's open records and maintenance agreements will provide a solid basis for the team's final cost of service analysis, deliverable under the present project work.

3.7.2.3 Complete database and integrate COS data into billing system

Broad meter data has been loaded into the database and a rates table created by meter type for utility billing purposes. The team is working with Clallam to get electronic data of the addresses and names of all the accounts that can be imported into the database. To this point, the PUD has been helpful with providing data and we believe we will be able to incorporate this data into the database over the coming quarter. As the next steps are completed toward a final COS analysis we will incorporate the information to create a final rate design to begin billing services. In these tasks the team is significantly ahead of schedule.

3.7.3 Objective 2 - Wind data analysis, Economics/Pricing Studies

12 month wind assessment has been completed. Data suggests a marginal annual wind resource but with a more reasonable capacity factor during the winter months. *(see John Wade and Bob Lynette 2004).* In prior discussions with BPA the prevalence of a winter peaking wind resource was valued (as discussed in previous quarterly reports). The team intends to investigate possible small wind installations under a winter peaking premium value.

3.7.3.1 Investigation of other Self-generation options

The team has been engaged in the evaluation of other potentially suitable forms of self generation that may lend themselves to a strategic portfolio of power options. Possibilities for self generation include small wind, bio-fuel, wave energy and others.

Last quarter, Wilde and Yockey traveled to Chehalis, WA to meet with a company that has developed, constructed and operated a proprietary system used for non-combustion cracking of organic waste products into fractional components of gas, oil and solids. The team has been investigating weather this techniques could be applicable for clean power technology self-generation at the Makah site.

In November, Wilde and Yockey visited a second commercial vendor of the same bio-gas technology in eastern Ohio. The company has developed a similar non-combustion process which cracks organic feed streams into gaseous, liquid and solid component parts. The gas can be burned to generate electricity, the liquid can be refined as bio-diesel and the solids are marketed separately. Depending on the feed stream material, gases can be generated which are rich in hydrogen and burn clean.

In considering this process for application in Neah Bay, the team first reviewed the possibilities of using discarded car tires as the feed stream. The process would require 40 tons per day to produce the required quantities of gas to generate 1 MW in a high efficiency CT. The team contacted the State of Washington ecology department in regard to assessing the amount of tire waste available on a continuing basis in the state. Although there are lots of store-housed waste tires, the logistical difficulties associated with supplying this level of consistent and voluminous feedstock make applications for this bio-gas process in Neah Bay challenging. The team has been investigating a variety of alternate organic (hydrocarbon) feed stocks to supply the process.

It was hypothesized that coal may provide an acceptable and attractive feed stream in light of its availability, price and energy density. Clean coal technology in which carbon remains sequestered has attractive potential. In November, two ten pound samples of coal were obtained and shipped one each to Conrad Industries in Chehalis, WA and the Eide's in Zanesville, OH. Each process vendor will process the coal samples in their process reactor and provide an analysis of the resulting component mix to the team. These results will be used to preliminarily assess the suitability of this process for application in Neah Bay.

3.8 Progress in Q1-2005

3.8.1 Summary

This report is the sixth quarterly report of the two year project. Work was accomplished in areas of formation of the Makah Tribal Utility Enterprise and in the further exploration of self generation options and associated economics and pricing studies

Progress toward evaluation and appraisal of the existing distribution assets took place during this quarter. A distribution expert was employed and on-site investigation of distribution assets and inspection of PUD records took place. A number of billing discrepancies and anomalies were uncovered in the investigation process. Report and cost recovery services are pending.

The team has continued its investigation into acceptable and feasible forms of self-generation, stressing clean renewable technologies such as small wind, bio-mass, waste recycling and wave generation. A small wind project was modeled and shown to be feasible on Cougar Hill, just south of Neah Bay. The team has also continued to investigate the business and engineering aspects of acquiring and operating the local distribution system by the tribal utility enterprise.

3.8.2 Objective 1 - Formation of the utility authority

3.8.2.1 Finalize Tribal Utility Enterprise Charter

The tribe's attorneys are still reviewing the charter but it is expected that it will be ratified and in place in the coming quarter.

3.8.2.2 Complete Appraisal and Negotiate Purchase of Distribution Assets

The team employed distribution expert, Richard Tucker, PE and conducted a site investigation of the distribution system and met with Clallam PUD during a visit in February. The components of the distribution system were inspected and assets identified by the team on Feb. 14, with Tucker paying particular attention to evidence of maintenance history, industry standard design, age of equipment and poles and major metering configurations.

While doing on-site inspection the team noticed primary metering configurations at the Tribal center. The team conducted an investigation aimed toward identifying misapplication of rates and inspected the bills to the Tribal center. According to the PUD tariff, primary metering provides for a substantial (6%) discount on all energy metered due to transformer losses absorbed by the customer. It was determined that the PUD has never provided the specified discount to the tribal accounts.

The team met with Clallam PUD on Feb. 15 and a tendered a specific list of questions and document requests as a result of inspection issues. Clallam agreed to provide records requested, and due to the fact that another municipality was in process of conducting due diligence on distribution purchase Clallam PUD already had much of the material gathered.

Further investigation revealed a misapplication of tariffs resulting in overcharges of approximately $3,500 per year for 17 years for a total of approximately $60,000. The statue of limitations may or may not apply for this situation. If it does only 3 years of overcharges will be available for collection.

In addition to the primary metering overcharge, a tax issue was also uncovered whereby all the individual tribal accounts were inappropriately charged a tax that was inadvertently built into the rates. The magnitude of this overcharge is yet to be determined.

During the next quarter, Tucker will complete his final analysis and report regarding the dollar value of the assets and the feasibility of operating the distribution system.

3.8.2.3 Determine scope of billing agency and draft an agreement for services

A draft agreement for setting up the “billing agency” was developed to make the Tribal Utility the official billing agent of end-users on the reservation. This document, when executed, will effectively put the Tribal utility between the incumbent LDC (Clallam PUD) and the tribal end-users. This is an important step toward establishing legitimacy and credibility for the utility and for developing autonomy from the PUD. There are two documents associated with this agreement. One is to be signed by the end-user the other to be sent to Clallam County PUD.

3.8.2.4 Further discussion with RUS

This item is dependent on appraisal numbers. Further discussion will be conducted with capital sources when the required level of funding has been ascertained through completion of appraisal, determination of operating expenses and completion of the cost of service analysis. RUS cost of money will then be compared with any other financing possibilities available.

3.8.3 Objective 2 - Wind data analysis, Economics/Pricing Studies

3.8.3.1 Investigation of other Self-generation options

The team has been engaged in the evaluation of potentially suitable forms of self generation that may provide strategic power portfolio options. Self generation sources include under investigation small wind, bio-gasification and wave energy.

Our previous investigation into a pyrolysis coal gasification process has been determined to have limited application to the Makah based on the logistical difficulties associated with shipping and storing the coal.

We have contacted a number of wave and tidal energy company's regarding potential testing of the Makah resource and with regard to the development of a meaningful and reliable wave generation program.

A complete set of wind data was obtained and used as the basis for wind resource modeling of a small wind energy project for the reservation. The model projects and investigates the economic viability of a single turbine installation on Cougar Hill as a means to supply below-cost power to various tribal building projects.

A GE Wind 1.5 MW turbine on an 80 M tower was shown to be feasible for installation on Cougar Hill adjacent to the new clinic and community center under construction by the tribe. The location and performance results are shown in Attachment 1.

The project would be structured under debt financing most likely in the form of a RUS low cost loan. The economics will be facilitated by a 30% equity ownership by an outside entity with a need for the after tax returns available form the PTC and 10 year depreciation.

<u>Model Project assumptions are as follows:</u>

- Single GE 1.5 MW turbine on 80 M tower
- 29% capacity factor (see data analysis)
- $2.043M install cost
- 70% RUS debt financing by Makah Tribal Utility
- 30% equity investment in return for 10-year post tax benefits
- All power used locally via interconnect to secondary side of Clallam PUD Neah Bay sub
- Displaced retail electricity cost of $70/MWH

<u>Based on Project assumptions above the following results are projected:</u>

- $58/MWH power at 20-year levelized cost to local load
- Equity investor 10-year Post tax IRR of 22.31%

With an additional grant funding of $250k which may be available from DOE or from other grant sources such as BPA or USDA, the price of power could be further reduced to a 20-year levelized cost of $55/MWH.

DOE offers development grants for this type of Native American project and in prior discussions with BPA the prevalence of a winter peaking wind resource was deemed of value. Additional value to BPA may be realized by the project providing a “non-wire solution” to future power needs on the Olympic Peninsula (as discussed in previous quarterly reports).

The Makah Tribe has development plans in place for a health facility and community center at Cougar Hill. The construction site is on the side of a hill due south of the town of Neah Bay. In addition to the development on Cougar Hill, plans for a new hotel to be built in Neah Bay are already in process. These tribal loads provide an ideal power displacement opportunity for the small wind generating facility. The project would further local economic development through low cost power whilst additionally providing tourist appeal through the use of green power at the new hotel.

The proposed location for the turbine installation is shown in Figure 4. Wind data analyses of the Tatoosh Island met site and the DOE 801 north site are shown in Figures 5 and 6.

It is interesting to note that a significant portion of the energy at the turbine site is derived from easterly winds. It is possible that the eastern exposure of the Cougar Hill project site is the reason that a capacity factor of 29% is predicted (Appendix 2) , which is significantly better than previously expected for west exposure.

It is also evident in Figs 5 and 6 that, not only are the high wind speed months clearly associated with the colder winter months as previously reported, but they are also associated with easterly winds. This suggests that wind turbines with eastern exposure may be more feasible on the Makah reservation.

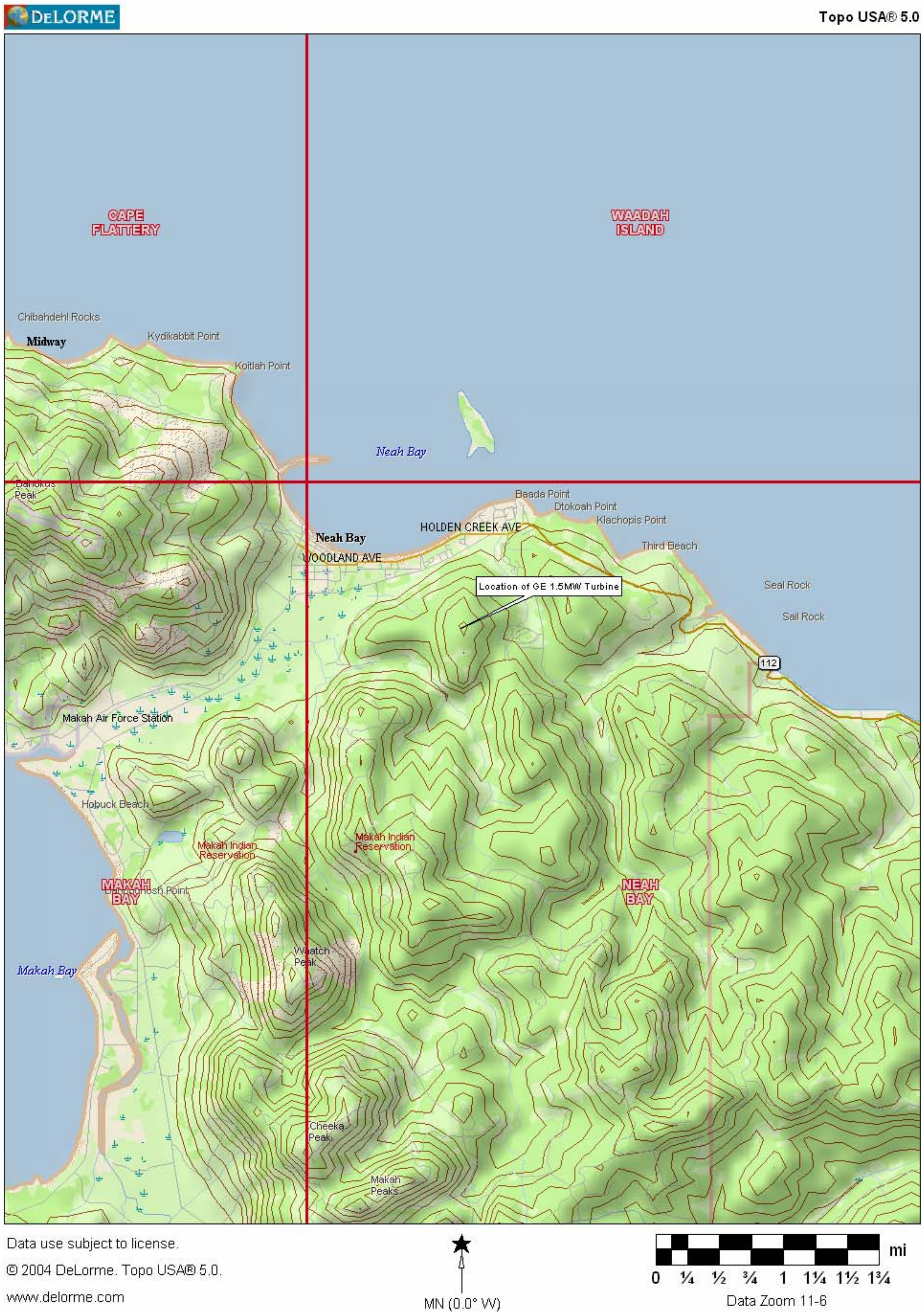
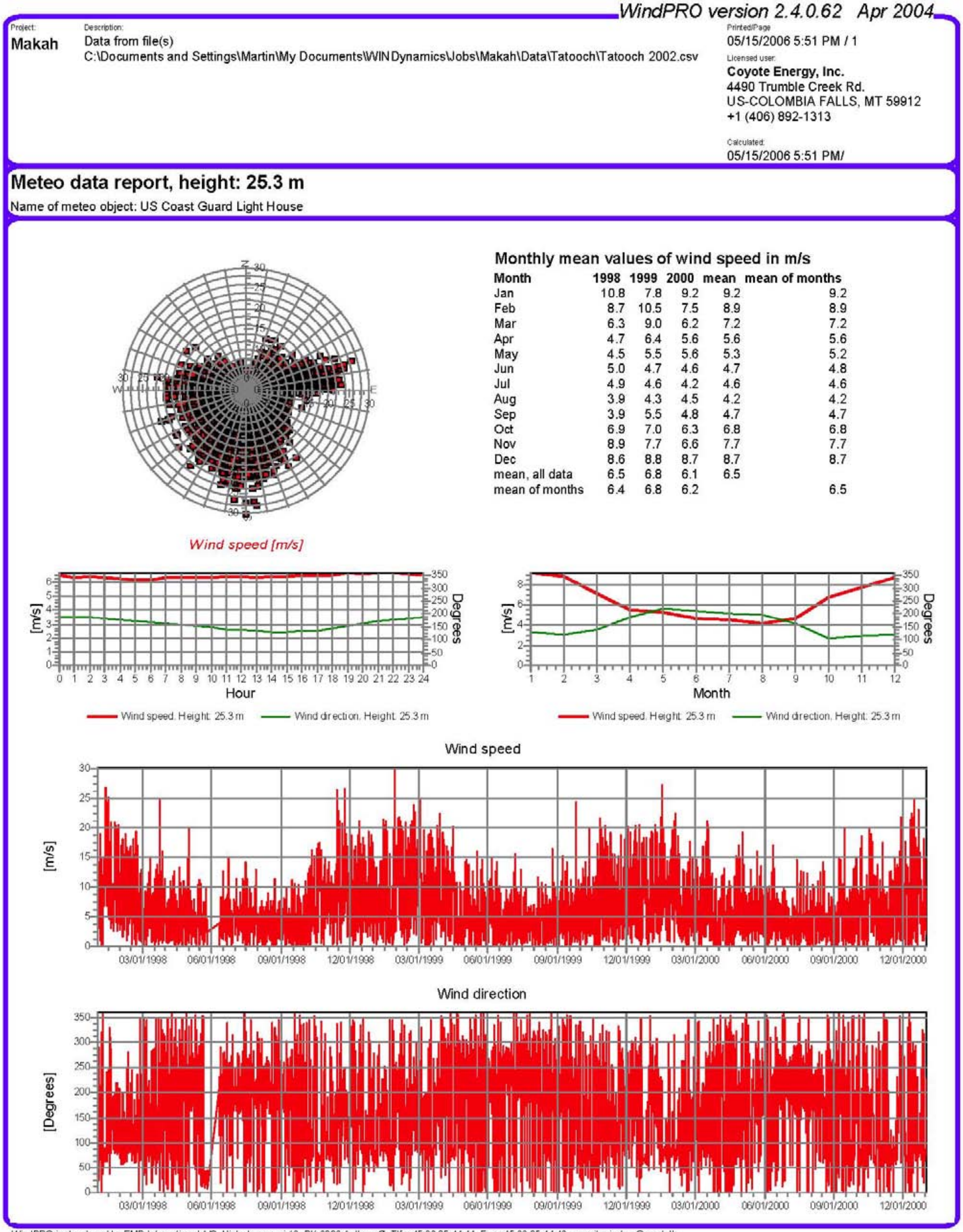


Figure 4 - Location of proposed turbine installation



WindPRO version 2.4.0.62 Apr 2004

Project:
Makah

Description:
Data from file(s)
C:\Documents and Settings\Martin\My Documents\WINDynamics\Jobs\Makah\Data\Tatooch\Tatooch 2002.csv

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+1 (406) 892-1313

Calculated:
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Meteo data report, height: 25.3 m

Name of meteo object: US Coast Guard Light House

Monthly mean values of wind speed in m/s

Month	1998	1999	2000	mean	mean of months
Jan	10.8	7.8	9.2	9.2	9.2
Feb	8.7	10.5	7.5	8.9	8.9
Mar	6.3	9.0	6.2	7.2	7.2
Apr	4.7	6.4	5.6	5.6	5.6
May	4.5	5.5	5.6	5.3	5.2
Jun	5.0	4.7	4.6	4.7	4.8
Jul	4.9	4.6	4.2	4.6	4.6
Aug	3.9	4.3	4.5	4.2	4.2
Sep	3.9	5.5	4.8	4.7	4.7
Oct	6.9	7.0	6.3	6.8	6.8
Nov	8.9	7.7	6.6	7.7	7.7
Dec	8.6	8.8	8.7	8.7	8.7
mean, all data	6.5	6.8	6.1	6.5	
mean of months	6.4	6.8	6.2		6.5

WindPRO is developed by EMD International A/S, Niels Jernesvej 10, DK-9220 Aalborg Ø, Tlf. +45 96 35 44 44, Fax +45 96 35 44 46, e-mail: windpro@emd.dk

Figure 5 Met data from Tatoosh Island Coast Guard station

WindPRO version 2.4.0.62 Apr 2004

Project:
Makah

Description:
Data from file(s)
C:\Documents and Settings\Owner\My Documents\Wind data\Makah\Data\801NFQ\801 North.txt

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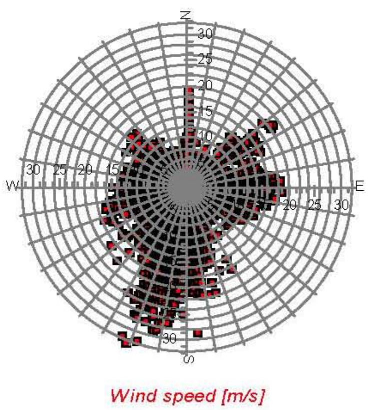
Calculated:
05/16/2006 5:23 PM/

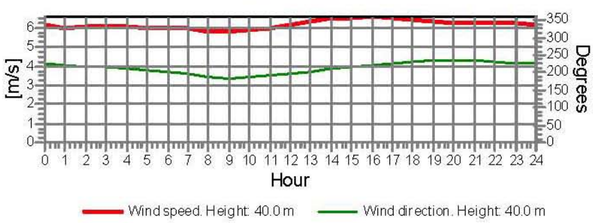
Meteo data report, height: 40.0 m

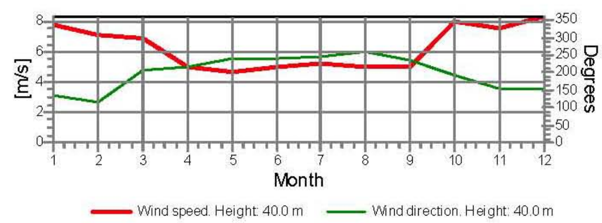
Name of meteo object: 801 North UTM 10 377755E 5357661N (NAD27)

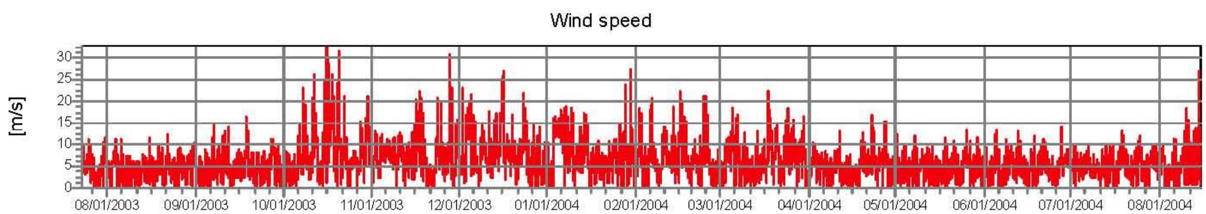


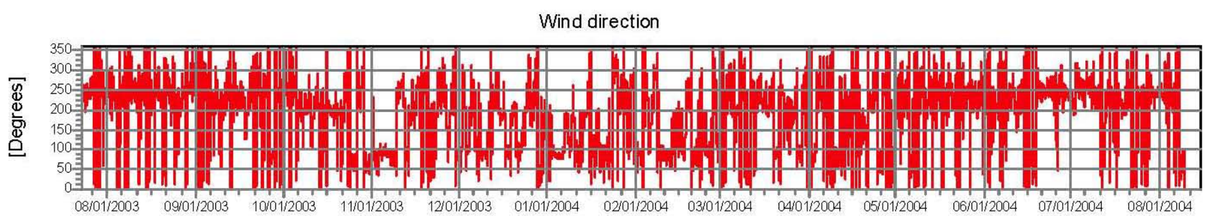
Monthly mean values of wind speed in m/s

Month	2003	2004	mean	mean of months
Jan		7.7	7.7	7.7
Feb		7.1	7.1	7.1
Mar		6.9	6.9	6.9
Apr		5.0	5.0	5.0
May		4.7	4.7	4.7
Jun		5.0	5.0	5.0
Jul	4.9	5.3	5.2	5.1
Aug	4.7	5.5	5.0	5.1
Sep	5.0		5.0	5.0
Oct	8.0		8.0	8.0
Nov	7.5		7.5	7.5
Dec	8.3		8.3	8.3
mean, all data	6.6	5.9	6.2	
mean of months	6.4	5.9		6.3









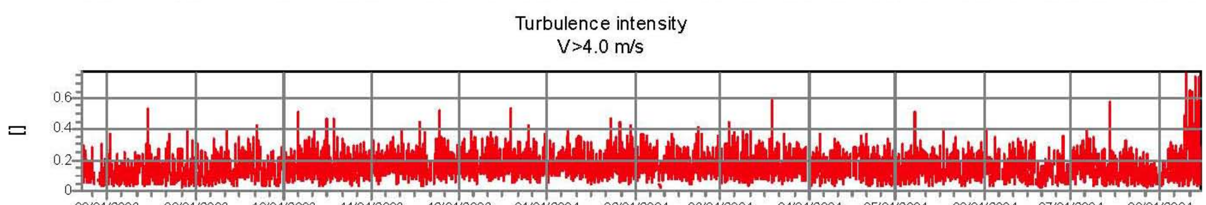


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Figure 6 - Met data analysis from 2002 DOE North Met site

3.8.4 Objective 6) - Negotiate Commercial Deal with Wind Developer to initiate construction

Requests for turbine quotes were made to GE Wind and to Suzlon. The actual costs for the turbine and maintenance will be entered into the cash flow model as they are received from the suppliers.

3.9 Progress in Q2-2005

3.9.1 Summary

This report is the seventh quarterly report of the two year project. Work was accomplished in areas of formation of the Makah Tribal Utility Enterprise, appraisal of distribution system assets and in exploration of self generation options and associated economics and pricing studies.

Detailed appraisal of distribution assets along with Operation and maintenance expenses were completed. These data were incorporated into a final cost of service model (COS). Final discussions on wheeling charges from Clallam are the last item yet to complete on this deliverable.

3.9.2 Objective 1 - Formation of the utility authority

3.9.2.1 Finalize Utility Charter

Corrections were made based on attorney input into the draft of the utility charter. A final draft of the Utility Charter is before the council and requires ratification. This is expected to be signed during the week of August 15.

3.9.2.2 Complete Appraisal and Negotiate purchase of Distribution Assets

A detailed appraisal for the entire distribution system was completed during this quarter with complete disclosure from Clallam PUD. Clallam's cooperation in this process ensures that confidence in the numbers arrived at in this appraisal is near 100%.

The pole birthmarks and age of the system were also fully disclosed and averaged between 32 years and 28 years of age for all major system components. Therefore, while the replacement cost came out to 1.1 million dollars (about 400K above our estimate) the system is almost fully depreciated with perhaps a year left on a 30 year depreciation schedule which means the purchase price is below our estimate. This information was then incorporated into the interim cost of service model.

3.9.2.3 Update Cost of Service Model

Based on appraisal numbers and a replacement cost less depreciation method for determining value, the capital costs to purchase facilities should be less than 100 K dollars. Therefore financing through RUS or some other means should not be a difficult matter.

The team also developed operations and maintenance expense figures in conjunction with typical figures provided by Clallam PUD. These numbers were used to produce an

O&M model proportional to power sales. By simplifying delivery cost expenses to a proportion of power sales the appropriate expenses to be expected after distribution purchase can be estimated with a high degree of accuracy.

The resulting cost of service model provides a strong base case from which to negotiate and do strategic planning going forward. This final model, along with the detail for capital costs, O&M expenses and a summary of the replacement cost for all facilities is attached in Appendix 1.

3.9.2.4 Discuss COS model with Tribe and incorporate into dBase

During the week of Aug 15 the Team will be discussing the results of our investigation with the tribal council. The COS model will be the basis for the rate design in the Tribal Utility billing system. The billing system itself is complete with respect to billing capability, account set-up and tables populated by customer information. All that is required is to determine the rates to charge.

3.9.2.5 Discussions with BPA and Clallam on PPA and wheeling charges

Once plant costs and delivery costs have been accurately modeled, the power purchase cost must be verified. The Team has assumed that the Makah utility would be a tier one customer for power purchase with BPA. While that appears certain for the short term strategic discussions for the long term are currently underway between BPA and regional stakeholders. A top priority for Makah is to engage in those discussions in order to make sure that the Makah can purchase power favorably in the medium to long term (10 – 30 years).

Our rate analysis was sent to a rate analyst with BPA in order to verify its accuracy. This verified number including transmission and ancillary services has been incorporated into the final COS model. The wheeling charges from Clallam remain to be refined.

With refined asset values and rates estimates, the Team can negotiate wheeling charges and ascertain how these rates will affect the final economic model for the utility. These points will be covered in discussions to be held with Clallam during the week of Aug 15.

3.9.3 Objective 2 - Wind data analysis, Economics/Pricing Studies

3.9.3.1 Obtain Turbine Quotes And Update Economic Model.

Turbine quotes were obtained from GE Wind and Suzlon for the single turbine installation contemplated for the Cougar Hill development. GE Wind quoted $1.46M/1.5MW based upon a turbine price for 18MW of installed capacity and Suzlon bid $1M/MW for 18.9 MW using their 2.1MW unit.

The GE Wind 1.5MW is expected to have a capacity factor of 29% and had a break even power price of around $73/MWH. The Suzlon 2.1 MW had a capacity factor of 27.3% in this resource and has an associated break even power price of $70/MWH.

3.10 Work Accomplished in Q3-2005

3.10.1 Objective 1 - Formation of the utility authority

3.10.1.1 Determine PUD Wheeling charges

During August 2005 discussions were held with Clallam PUD to determine what the wheeling charge would be from the Sappho substation to Neah Bay – the PUD provided a rate of $.002 per kWh. This rate was incorporated into the final COS model and provides a final base case for the Makah Tribal Utility.

The economics described in the COS model indicate that, even with full purchase of the distribution assets, the Makah Nation's cost of service would be slightly below the current costs.

Current costs average around 7¢ per kWh from the PUD compared to all in costs for the Makah at 6.3¢ per kWh. This 6.3 ¢ includes a contingency fund of .85¢ to develop surplus so that phased upgrades to distribution can be done through leveraged loans. A prudent rate strategy would be to charge the same rate as currently charged in order to capture extra margin for upgrade purposes. It was determined through this study that either a phased or complete distribution takeover is financially feasible.

Other issues with regard to Tribal operational capacity and feasibility must be determined by the Tribal council.

3.10.1.2 Finalize Utility Charter

A final draft of the Utility Charter is before the council and requires ratification.

3.10.1.3 Complete Appraisal and Negotiate purchase of Distribution Assets

A detailed appraisal for the entire distribution system was completed under this study with complete disclosure from Clallam PUD. Clallam's cooperation in this process ensures that confidence in the numbers arrived at in this appraisal is near 100%.

3.10.1.4 Update Cost of Service Model

The final COS model, along with the detail for capital costs, O&M expenses and a summary of the replacement cost for all facilities is attached in Appendix 1.

3.10.1.5 Discuss COS model with Tribe and incorporate into dBase

The billing system is complete with respect to billing capability, account set-up and tables populated by customer information.

3.10.2 Objective 2 - Wind data analysis, Economics/Pricing Studies

It was determined that there may be feasibility in using wind power on Cougar Hill adjacent to new development in Neah Bay.

3.10.3 Objective 4 - Environmental Profile and Mitigation Strategy

It was determined that small wind installations would likely be feasible in terms of environmental impact.

3.10.4 Objective 5 - Marketing of Power

Export and marketing of bulk power from the Makah reservation was determined to be unfeasible.

4 Products Developed Under The Award And Technology Transfer Activities

No patents resulted from this award.

An URL was purchased on behalf of the Tribe by the name of “makahenergy.com”. The Tribe currently has a portal which provides community information and it was discussed that the utility database would be accessed via the community bulletin board. However, no decision was made in this regard. The database is web service enabled allowing it to be linked through a metadata level if the Tribe decides to do so.

A database was developed to provide customer information and billing functions for the Tribal utility. This database was written in a language called 4-D is compatible with Oracle and is fully web-service enabled. The database provides the ability to add meter readings, calculate rates, generate invoices and provide basic accounting reports necessary to operate an electric utility.

The database has not yet been populated with customer data. It was planned that a combination of data from the PUD and the 911 database would provide the most complete records. Until the Tribe decides to move forward with the MEE charter this data has not been added.

5 Computer Modeling

Wind data analysis and project outputs were modeled using WindPRO 2.4. WindPRO is a Windows 98/ME/NT/2000/XP modular based software suite for the design and planning of both single wind turbine generators (WTG’s) and wind farms. The program version used in this work is equipped with three modules BASIS, METEO and PARK. All layouts were done over 1:24,000 scale DEM’s which were correlated and scaled to raster topographic maps.

A project name is defined and digital or scanned maps of the site are loaded into the PC. WindPRO is comparable and compatible with WaSP and imports and defines Surface Roughness, Local Obstacles and Topography directly on-screen. These data are automatically registered with coordinates and elevation from the DEM.

The BASIS module is used for Project Administration, Map Handling, WTG Catalogue, Wind Data and on-screen digitalization of Height Contour Lines. Included in the WTG Catalogue are the turbines under investigation in this project. METEO is used to Import, analysis and long-term correction of measured wind data (logger data) and Calculates

WTG yield. The PARK module conducts Array loss/wind farm calculations based on any of the BASIS module.

6 Appendix

6.1 Appendix 1 – Final COS model

Makah - Electric Utility

CASE # 1

Cost of Service Analysis (in nominal dollars)

Annual and Five Year Savings Analysis (in nominal dollars)

Current load with no load growth

Capital Cost

Replacement cost less depreciation	$	38,018	

Load

PUD Supplied		16,722,876	
Purchased Power		-	
Self Generation		-	
		16,722,876	kWh

Retail Energy Rate

Clallam County PUD (variable energy)		0.0652	
Clallam County PUD (fixed plant)		0.0056	
	$	0.07076	per kWh

Wholesale Energy Rates BPA PBL

Demand Charge		0.0065	
HLH energy rate		0.0151	
LLH energy rate		0.0118	
Load variance rate		0.0011	
Total Wholesale Cost	$	0.03449	per kWh

MEE Delivery Costs

BPA TBL		0.0031	
O&M Distribution		0.0053	
PUD Wheeling		0.0020	
Customer Accounts		0.0030	
Customer Service		0.0003	
General and Administrative		0.0052	
Plant and Debt @ 5% for 30 years		0.0008	
Losses		-	
Outsourcing and Contingency		0.0085	
Cost of Delivery	$	0.02818	per kWh

Total Delivered Cost/kWh to End Use

Weighted wholesale plus cost of delivery	$	0.06267	per kWh

Total Delivered Cost to End Use - Annual

Current Average Rate	$	1,183,275
MTU Rate	$	1,048,028

First Year Savings by MUC Compared to Staying with Current Supplier

$ 135,247

Five Year Savings by MUC Compared to Staying with Current Supplier

$ 676,235

6.2 Appendix 2 - Wind data modeling for single turbine at Cougar Hill site

WindPRO version 2.4.0.62 Apr 2004

Project: **Makah**
Description: Makah Indian Reservation

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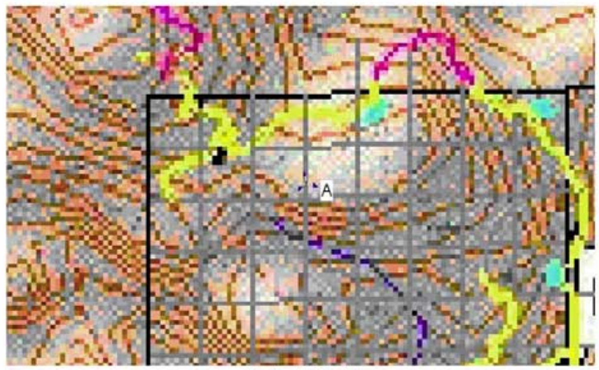
Calculated: 10/14/2005 3:48 PM/2.4.0.62

METEO - Main Result

Name 801 North UTM 10 377755E 5357661N (NAD27)
Site Coordinates
UTM NAD27 Zone: 10 East: 377,755 North: 5,357,661
Air density 1.204 kg/m3
Height above sea level 150 m
Mean temperature 15.0 °C

Calculation is based on "801 North UTM 10 377755E 5357661N (NAD27)", giving the Weibull distribution for the wind speed on the site.
Using the selected power curve, the expected annual energy production is calculated.



Scale 1:25,000

Meteorological Data

Weibull data 40 m above ground level

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]	Wind gradient exponent
0 N	4.93	4.58	1.263	3.2	0.031
1 NNE	4.38	3.90	1.776	2.8	0.044
2 ENE	5.86	5.23	1.728	6.9	0.185
3 E	8.36	7.40	2.200	14.5	0.154
4 ESE	6.96	6.17	2.309	4.8	0.128
5 SSE	6.01	5.39	1.595	2.2	0.098
6 S	11.20	9.94	1.894	8.7	0.002
7 SSW	7.12	6.55	1.324	15.6	0.005
8 WSW	6.08	5.38	2.313	22.9	0.026
9 W	6.14	5.44	2.136	12.7	0.096
10 WNW	6.64	5.89	2.322	4.1	0.117
11 NNW	5.13	4.56	1.783	1.7	0.150
All	6.97	6.23	1.654	100.0	

Calculation Results

Key results for height 50.0 m above ground level
Wind energy: 2,956 kWh/m2; Mean wind speed: 6.3 m/s;

Calculated Annual Energy

WTG type						Power curve		Annual Energy			
Valid	Manufact.	Type	Power [kW]	Diam. [m]	Height [m]	Creator	Name	Result [MWh]	Result-10% [MWh]	Mean wind speed [m/s]	Capacity factor [%]
Yes	GE WIND ENERGY	GE 1.5sle	1,500	77.0	80.0	EMD	Man. 12-2004	3,901.5	3,511	6.5	29.7
Yes	GE WIND ENERGY	GE 2.7	2,700	84.0	70.0	EMD	Man. 09-2003	5,210.2	4,689	6.5	22.0
No	Suzlon		2,100	0.0	80.0	USER	1.19 density 240M elevation	5,177.0	4,659	6.5	28.1
No	VESTAS	V66	1,800/300	66.0	67.0	EMD	Vestas 02-02-1999 1.225 25.00 0.00	3,263.0	2,937	6.4	20.7

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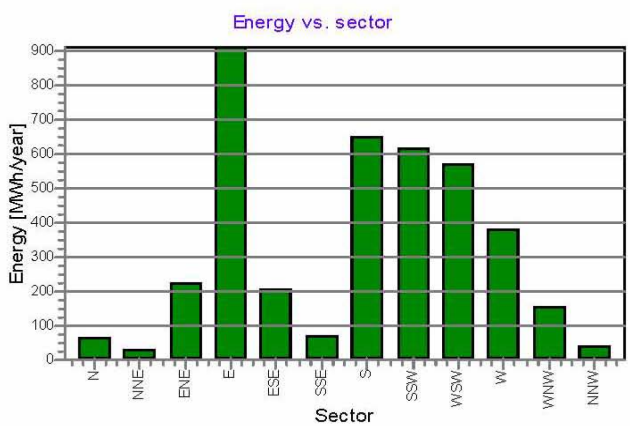
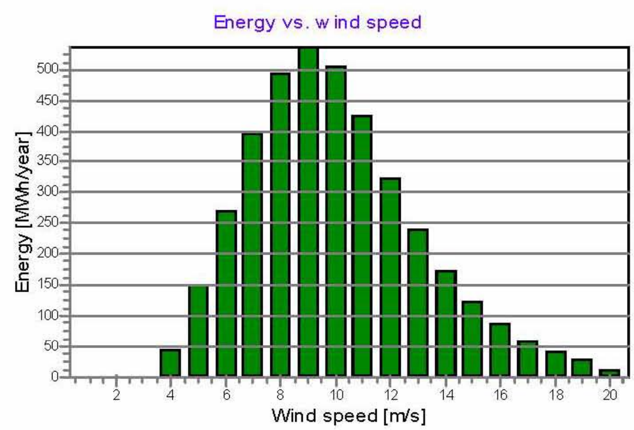
METEO - Production Analysis

WTG: GE WIND ENERGY GE 1.5sle 1500 77.0 !O!, Hub height: 80.0 m, Air density: 1.204 kg/m3

Directional Analysis

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	62.5	29.0	226.5	909.1	206.9	67.8	648.1	612.6	567.8	380.7	152.6	37.8	3,901.5
Resulting energy	**[MWh]**	**62.5**	**29.0**	**226.5**	**909.1**	**206.9**	**67.8**	**648.1**	**612.6**	**567.8**	**380.7**	**152.6**	**37.8**	**3,901.5**
Specific energy	[kWh/m2]													838
Specific energy	[kWh/kW]													2,601
Directional Distribution	[%]	1.6	0.7	5.8	23.3	5.3	1.7	16.6	15.7	14.6	9.8	3.9	1.0	100.0
Utilization	[%]	34.1	36.7	35.0	28.9	37.0	34.1	17.8	25.7	40.0	38.8	38.3	38.1	28.4
Operational	[Hours/year]	235	202	502	1,066	355	160	639	1,140	1,677	930	298	127	7,332
Full Load Equivalent	[Hours/year]	42	19	151	606	138	45	432	408	379	254	102	25	2,601
A- parameter	[m/s]	5.0	4.5	6.7	9.3	7.6	6.4	11.2	7.1	6.2	6.6	7.2	5.7	7.3
Mean wind speed	[m/s]	4.5	4.0	5.9	8.2	6.8	5.7	9.9	6.4	5.5	5.8	6.4	5.0	6.5
k- parameter		1.58	2.10	2.05	2.52	2.63	1.91	2.21	1.64	2.63	2.46	2.64	2.10	1.94
Frequency	[%]	3.2	2.8	6.9	14.5	4.8	2.2	8.7	15.6	22.9	12.7	4.1	1.7	100.0
Power density	[W/m2]													333





Project: **Makah**
Description: Makah Indian Reservation

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METEO - Power Curve Analysis

WTG: GE WIND ENERGY GE 1.5sle 1500 77.0 !O! Man. 12-2004, Hub height: 80.0 m

Name: Man. 12-2004
Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
12/23/2004	EMD	11/21/2000	01/12/2005	20.0	Pitch	User defined

Based on release 4Q04

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2,147	3,366	4,628	5,833	6,826	7,716
GE WIND ENERGY GE 1.5sle 1500 77.0 !O!	[MWh]	2,201	3,466	4,697	5,757	6,568	7,111
Check value	[%]	-2	-3	-1	1	4	9

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTG's performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

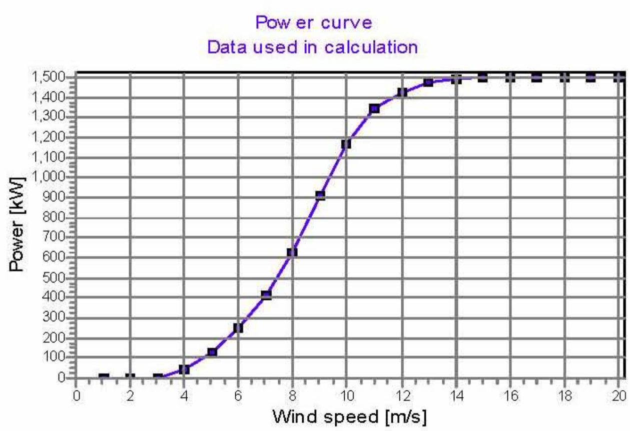
Original data from Windcat, Air density: 1.225 kg/m3

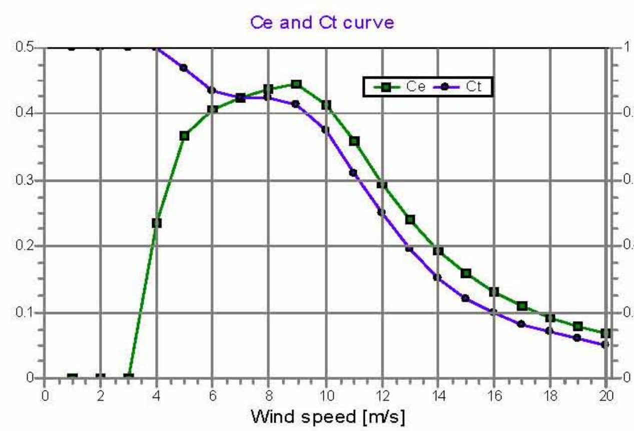
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
4.0	43.0	0.24	4.0	1.09
5.0	131.0	0.37	5.0	0.94
6.0	250.0	0.41	6.0	0.87
7.0	416.0	0.43	7.0	0.85
8.0	640.0	0.44	8.0	0.85
9.0	924.0	0.44	9.0	0.83
10.0	1,181.0	0.42	10.0	0.75
11.0	1,359.0	0.36	11.0	0.62
12.0	1,436.0	0.29	12.0	0.50
13.0	1,481.0	0.24	13.0	0.39
14.0	1,494.0	0.19	14.0	0.30
15.0	1,500.0	0.16	15.0	0.24
16.0	1,500.0	0.13	16.0	0.20
17.0	1,500.0	0.11	17.0	0.16
18.0	1,500.0	0.09	18.0	0.14
19.0	1,500.0	0.08	19.0	0.12
20.0	1,500.0	0.07	20.0	0.10
21.0	1,500.0	0.00	21.0	0.09
22.0	1,500.0	0.00	22.0	0.07
23.0	1,500.0	0.00	23.0	0.07
24.0	1,500.0	0.00	24.0	0.06
25.0	1,500.0	0.00	25.0	0.06

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1.204 kg/m3

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc.Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50- 1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50- 2.50	0.0	0.0	0.0
3.0	0.0	0.00	2.50- 3.50	0.0	0.0	0.0
4.0	42.3	0.24	3.50- 4.50	45.9	45.9	1.2
5.0	128.8	0.37	4.50- 5.50	149.3	195.3	5.0
6.0	245.7	0.41	5.50- 6.50	271.4	466.7	12.0
7.0	408.9	0.43	6.50- 7.50	395.0	861.7	22.1
8.0	629.0	0.44	7.50- 8.50	493.3	1,355.0	34.7
9.0	908.2	0.44	8.50- 9.50	535.5	1,890.5	48.5
10.0	1,163.4	0.42	9.50-10.50	505.4	2,395.9	61.4
11.0	1,342.8	0.36	10.50-11.50	422.5	2,818.4	72.2
12.0	1,423.1	0.29	11.50-12.50	324.8	3,143.3	80.6
13.0	1,472.2	0.24	12.50-13.50	239.1	3,382.4	86.7
14.0	1,489.5	0.19	13.50-14.50	172.3	3,554.7	91.1
15.0	1,500.0	0.16	14.50-15.50	122.3	3,677.0	94.2
16.0	1,500.0	0.13	15.50-16.50	85.6	3,762.6	96.4
17.0	1,500.0	0.11	16.50-17.50	59.3	3,822.0	98.0
18.0	1,500.0	0.09	17.50-18.50	40.7	3,862.7	99.0
19.0	1,500.0	0.08	18.50-19.50	27.7	3,890.4	99.7
20.0	1,500.0	0.07	19.50-20.50	11.2	3,901.5	100.0





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METEO - Wind Data Analysis

Wind data: A - 801 North UTM 10 377755E 5357661N (NAD27); Hub height: 40.0

Weibull Data

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]	Wind gradient exponent
0 N	4.93	4.58	1.263	3.2	0.031
1 NNE	4.38	3.90	1.776	2.8	0.044
2 ENE	5.86	5.23	1.728	6.9	0.185
3 E	8.36	7.40	2.200	14.5	0.154
4 ESE	6.96	6.17	2.309	4.8	0.128
5 SSE	6.01	5.39	1.595	2.2	0.098
6 S	11.20	9.94	1.894	8.7	0.002
7 SSW	7.12	6.55	1.324	15.6	0.005
8 WSW	6.08	5.38	2.313	22.9	0.026
9 W	6.14	5.44	2.136	12.7	0.096
10 WNW	6.64	5.89	2.322	4.1	0.117
11 NNW	5.13	4.56	1.783	1.7	0.150
All	6.97	6.23	1.654	100.0